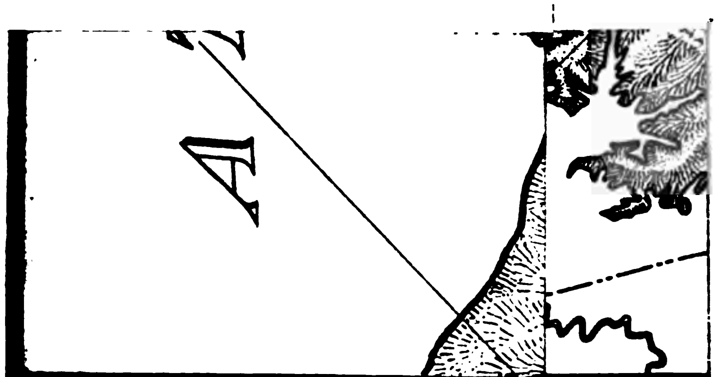

ANNUAL REPORT OF THE

ISTHMIAN CANAL COMMISSION

FOR THE FISCAL YEAR ENDED JUNE 30

1908

WASHINGTON
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ANNUAL REPORT

OF THE

ISTHMIAN CANAL COMMISSION.

CULEBRA, CANAL ZONE, *August 25, 1908.*

SIR: I have the honor to submit, on behalf of the Isthmian Canal Commission, its annual report for the fiscal year ended June 30, 1908.

ORGANIZATION OF THE COMMISSION.

The membership of the commission continued without change during the year. Early in June Mr. Jackson Smith tendered his resignation, effective September 15, 1908, and entered upon two months' leave of absence, beginning July 16. Lieut. Col. H. F. Hodges, Corps of Engineers, U. S. Army, was appointed to succeed him, and was assigned to duty under the commission during the interim; he reported for duty on the Isthmus July 14, 1908.

The executive order of January 6, 1908, combined several existing orders and defined the duties of the commission more clearly, transferring to the chairman certain details which the order that it superseded had delegated to the commission.

CONSTRUCTION AND ENGINEERING.

The organization of the department of construction and engineering is given in detail in the last annual report of the commission, and the several departments and divisions therein outlined were continued throughout the year, except that in consequence of the change in the location of the locks on the Pacific side, hereinafter described, the Pacific division of locks and dams was substituted for the La Boca locks and the La Boca dams division. Briefly, the department of construction and engineering consisted of 3 departments and 12 divisions; each division had its independent administrative organization and reported through the head of the department to which it belonged.

Under the organization as it existed buildings were erected, roads built, and sanitary ditches dug or constructed in the same territory in which canal work was in progress, but in each specific instance,

under a separate head; the results were not always satisfactory. In order to concentrate authority, to expedite the transaction of business, to secure proper coordination, to fix definitely the responsibility in any particular case, and to reduce the cost of administration, a complete reorganization was undertaken toward the close of the fiscal year, to be effected gradually, beginning July 1, by which all construction work, in any given district, irrespective of its character, would be placed under one head, the necessary authority having been received from the Secretary of War for the transfer of duties as between departments, required by executive order of January 6, 1908. The reorganization was desirable because the work of the divisions of building construction and municipal engineering had reached a stage where the continuance of separate divisions for handling the work was unwarranted, and was facilitated by the consent and approval of the chief sanitary officer to have the sanitary engineering work hitherto performed by his department done by the canal construction forces in accordance with plans and on data prescribed and furnished by the department of sanitation.

A further advantage sought by the reorganization was the establishment of a more uniform wage scale, and to secure it the organization was put on an impersonal basis by fixing the positions needed to properly execute the work and the salary that each position should carry. To the positions thus found necessary the available personnel was fitted so far as possible.

To accomplish the objects sought, the zone was divided into three parts, each of which is to constitute a division under the department of construction and engineering, the division engineers reporting direct to the chief engineer. The first is to include all territory north of Tabernilla, to be designated the Atlantic division; the second is to extend from Tabernilla to Pedro Miguel, to be named the central division, and the third, extending from Pedro Miguel to deep water in the Pacific, will constitute the Pacific division. As the reorganization is not complete at this time, its details must be left for the next annual report.

EXCAVATION AND DREDGING.

This department embraced the Culebra division, the Chagres division, the Colon dredging division, and the La Boca dredging division. To the equipment for excavation in the dry, reported on hand at the close of the last fiscal year, fourteen 70-ton steam shovels, sixteen 95-ton steam shovels, 292 Lidgerwood cars, and six hundred and sixty-eight 12-yard dump cars were added by receipt or purchase during the year. With the addition of 200 dump cars, it is anticipated that the locomotives, steam shovels, and cars on hand or under order will be sufficient to complete the work to be done by this class of equipment.

Culebra division.—This division extended from the Chagres River in the vicinity of Gamboa to include the Pedro Miguel lock, a distance of 9.2 miles; the total amount of material excavated in the Culebra division during the year was 12,065,138 cubic yards, place measurement, of which 11,685,253 cubic yards were from the canal prism and the balance for accessory works. The total number of steam shovels assigned to this part of the work during the year was 59.

As practically all the areas suitable for dumps within the limits of the division were utilized to their fullest capacities, the greater part of the material was hauled over the main line of the Panama Railroad to Gorgona and Tabernilla on the north and to the new dumps at Miraflores and La Boca on the south, the average haul being about 10 miles. The last two dumps were developed during the year—the former is on the relocation of the Panama Railroad, and the latter, while originally intended for use in connection with the stone-crushing and constructing plant of the La Boca locks, is utilized since the abandonment of this locality for lock purposes as a jetty to stop the drift of silt from the east which is deposited in the dredged channel. Rock from the "cut" at Bas Obispo has been taken to Gatun, and since March 20, 1908, about 1,300 cubic yards have been deposited daily on the south toe of the dam between the lock site and the temporary spillway, forming part of the dam.

For construction purposes, and for maintenance subsequent to the completion of the canal, it is necessary to divert the waters flowing into the "cut" from adjacent watersheds. With this in view, the French diversion channel for the Camacho River, on the west side of the canal, was utilized. A new channel, revetted with stone, was cut through white house yard, the French tunnel through the hill at Bas Obispo was cleared out, and a dam was constructed across the Obispo River. This is known as the Camacho diversion and carries the waters from Culebra to the Chagres River, near Matachin.

The survey for diverting the Obispo River and the other streams on the east side of the canal was completed, a new channel located and its construction pushed as rapidly as possible. During the year the channel was finished from Gold Hill to a point opposite Las Cascadas, with work in progress between this point and Gamboa. This, known as the Obispo diversion, will carry the waters into the Chagres River about 1 mile above the crossing of the river by the canal; 313,511 cubic yards of material were removed during the year, and 400,000 remain to be excavated in order to complete it.

On October 4 the Cucaracha slide, which had caused more or less inconvenience since the work was begun by the French in 1884, started to move toward the east edge of the canal at a rate, at first, of 14 feet in twenty-four hours, decreasing toward the close of the

month to about 4 feet in the same period of time. About 113,000 cubic yards of material moved so as to effectually stop the transportation of material through the "cut" to the south, and necessitated the handling of all material over the single-track portion of the Panama Railroad via Empire to the south. Work was prosecuted, without interruption, day and night, by steam shovels and improvised hydraulic means, and by the end of the month sufficient space was gained on the moving mass to permit the passage of dirt trains to the south over the old route. The total area of the slide was approximately 34,455 square yards, and it was estimated that about 600,000 cubic yards were in motion. The removal of this slide is not a source of difficulty in the dry season. A wide berm was left with the hope that should rapid movement again take place, steam shovels could prevent the interruption of traffic.

The slide at Paraiso, another which developed when the French were at work on the canal, gave trouble in April of this year. It is located on the east bank of the canal and extends up a narrow gorge for about 750 feet from the edge of the canal. The estimated area is 16,700 square yards, and the amount in motion is about 140,000 cubic yards, of which about 90,000 cubic yards have been removed.

Two slides developed in the dry season along the upper level of Culebra "Cut." One is situated on the west bank of the canal at the village of New Culebra, which is built on one of the French dumps. The most distant point of the slide from the "cut" is about 420 feet; the area is approximately 6,110 square yards and about 50,000 cubic yards of material are in motion. The other slide is located nearly opposite the village of Las Cascadas, on the east bank of the canal and extends back from the edge of the canal for a distance of about 230 feet. The area of this slide is estimated to be 5,433 square yards, and about 100,000 cubic yards of material are in motion.

At the new Culebra station a sinking of the ground surface west of the west slope of the "cut" was noticed and a corresponding uplift of the bottom of the "cut" took place. A similar action of the bottom occurred in the canal just south of Gold Hill. In both instances this upward movement of the bottom was stopped by removing the material on the upper levels, whereby the pressure was reduced.

Chagres division.—This division covered a distance of about 23 miles and extended from Gatun to a point where the canal crosses the Chagres River at Gamboa. The river crosses the canal line 23 times within the limits of this division, so that during construction a considerable portion of the prism is subject to overflow by floods, and to such an extent that progress of work is liable to be slow during the rainy seasons.

The surveys reported as in progress in the last annual report were completed, and the center line of the canal permanently marked. Slight changes in the alignment were made in the final location whereby a saving of 1,264,700 cubic yards was effected; of this, 264,300 cubic yards were rock. These surveys show that the total amount to be removed from this part of the canal prism is 12,256,300 cubic yards, of which 8,313,500 cubic yards are earth and the balance rock.

During the fiscal year excavation was begun on four different sections. At San Pablo work was commenced in August and 634,832 cubic yards were removed during the balance of the year; there remain to complete this section 744,807 cubic yards. Work was begun at Caimito on October 1; the estimated amount of material to be removed from this section is 2,079,493 cubic yards, of which 555,346 cubic yards were excavated during the year. In the vicinity of Matachin 1,552,000 cubic yards are to be removed, and 434,151 cubic yards were taken out since December 30, when work was commenced. At Santa Cruz, between Matachin and the Chagres River, the removal of 1,277,800 cubic yards is necessary to secure the prism, and of this amount 138,896 cubic yards were excavated since February 24.

The total amount of material excavated was 1,774,124 cubic yards, place measurement, all from the canal prism.

The sections at Santa Cruz and Matachin are at present most liable to overflow from the Chagres, and levees with proper flood drains were built at the ends of the cuts for protection against the medium flood stages of the river; sumps were dug and pumps installed for the purpose of draining the sites from seepage and rain water.

The total number of steam shovels in operation in this division was 15 and the balance of the equipment is largely that left by the French; 47 out of a total of 50 engines in use are French, as are 410 of the 645 dump cars.

Colon dredging division.—This division extended from the foot of Gatun lock to deep water in the Caribbean Sea, and embraced the Mindi and Colon districts and the Cristobal marine shops. The survey of the Mindi district was completed and the clearing between Mindi and Limon Bay was finished in August. Excavation by steam shovels was begun in July, and two of them removed a total of 536,959 cubic yards, including both swamp and rock. A levee was constructed along the low part of the prism to protect the cut from the waters of the French canal, and a sump was dug and a pump installed to remove water accumulating in the cut through seepage and rain.

Dredging during the year was done by two French ladder dredges, two dipper dredges, the 16-inch suction dredge, and by the seagoing suction dredge *Ancon*. A total of 5,087,623 cubic yards of material

was removed, of which 4,947,330 cubic yards were from the canal prism and the remainder from accessory works.

Some additional machinery was installed in the machine shop adjacent to the dry dock and maintained the various dredges, clapets, and tugs in good working order. Some further additions will be made so that the shops can care not only for the dredging plant but also for the tugs, barges, and dredges to be used in handling stone, sand, and other material required for the Gatun locks and dam. Three dredges were received, knocked down, from the United States for the Gatun dam division and erected at the shops, pontoons and pipe lines being built for them; two are completed and the other is well under way.

The enlargement of the dry dock begun during the previous fiscal year was completed, making it capable of taking a vessel 298 feet long, 50-foot beam, and 15-foot draft.

La Boca dredging division.—The change in the location of the locks and dams on the Pacific side extended the limits of this division about 3 miles, the area to be dredged extending from the Miraflores locks to deep water in the Pacific, a distance of about 8 miles, with a width of 500 feet. The quantity of material to be removed is estimated at 29,212,700 cubic yards, at least 1,500,000 cubic yards of which is rock. To obtain accurate information as to the amount and character of rock, three lines of borings are being made along the center and side lines of the channel for every 100 feet of distance. The purchase of a drill scow and one Lobnitz rock breaker for breaking up the rock so that it can be handled by the dredges was arranged, and the results of the experiments with these two machines will determine the method of removal finally adopted.

With the abandonment of the lock site at La Boca, a slight change in the alignment of the new channel was made, so as to utilize the present wharves of the Panama Railroad Company, as well as the dredging already done under the former project and by the French. With the exception of a small cut made by the dipper dredge, all excavation done under the original plan is within the limits of the new channel.

There have been used on this stretch of the canal the seagoing suction dredge *Culebra*, which went into commission on January 1, and four French ladder dredges. The dipper dredge was taken out of commission on January 17, 1908, as not suitable for handling the soft material, and will be utilized later in the removal of rock. During the fiscal year a total of 5,273,369 cubic yards was removed, of which 5,264,019 cubic yards were from the canal prism and 9,350 cubic yards from accessory works.

During January one of the construction tracks of the lock division was extended to Cardenas Hill, and early in February a steam shovel

was put at work removing the hill, the spoil of which is dumped along the east bank of the Rio Grande parallel to the canal line, forming a dike to confine the material from the channel that will be excavated and pumped behind it by a suction dredge. Of this dike, 300 feet were finished and 1,600 feet partially completed, utilizing 55,490 cubic yards of material taken from the prism.

Repairs were made at the La Boca shops to the various dredges, clapets, and tugs on the Pacific side; and a 20-inch suction dredge, the material for which was received during the early part of the fiscal year from the United States, was erected. The boat was launched on May 17 and the machinery is being installed; complete equipment of pontoons and pipe lines for the dredge was also made. By the change in the location of the locks these shops will not be flooded as under the original project, and they are being put into condition for permanent use.

In Appendix A will be found more in detail the work done by the department of excavation and dredging during the year.

LOCKS AND DAMS.

This department of construction embraced the Gatun locks and the Gatun dam divisions, the Pacific division of locks and dams, and the division of meteorology and river hydraulics.

The locks are in pairs, and since the compilation of the last annual report the projected dimensions have been increased so that the width in the clear will be 110 feet, the usable length remaining, as heretofore, 1,000 feet. The question of increasing the width was raised by the General Board of the Navy, in a memorandum to the Secretary of the Navy, dated Washington, October 29, 1907, setting forth "that the width of the locks as now fixed, namely, 100 feet, is insufficient for probable ships of future construction, and that sound policy would dictate an increase to a clear width of 110 feet."

While the commission, after due consideration, was of the opinion that the width already adopted for the locks—100 feet in the clear—was ample for all commercial vessels building or contemplated, and sufficient for any battle ship constructed, building, or projected, it felt that the wishes of the Navy, as expressed by the General Board, should be followed, there being no insuperable obstacles, and it accordingly recommended that the project be modified as desired. This modification was approved by the President, under date of January 15, 1908.

The project prepared by the minority members of the board of consulting engineers for the lock type of canal provided for a flight of three locks at Gatun, a flight of two locks at La Boca, and one at Pedro Miguel. The locks at La Boca were placed on the west side of

Sosa Hill, and were to overcome the difference of the level between the ocean and a lake formed by the Sosa-Corozal and the Sosa-San Juan dams. Steps were taken to construct the former of these dams in accordance with the proposed plan, and trestles were built along the toes from which to dump material from Culebra cut. The trestles failed after the dumping from them began, and the material overlying the rock moved laterally, carrying the superimposed mass with it. In places this lateral motion continued for two weeks after dumping had stopped. The ground on either side of, and for some distance from, the dump was forced up, forming mounds of mud, the crests of which gradually approached the level of the dump proper. After an equilibrium was established between the dump and the adjacent mounds the hump or wave would again move out when the track was shifted toward it, accompanied by a sudden vertical settling of the track of 6 to 10 feet when loaded trains were applied. Dumping from trestles of less height secured no better results.

When the difficulty developed, investigations by borings and test pits were made to determine the character of material overlying the rock. It was found to be, for the greater part, an unctuous blue clay without grit, possessing very little supporting power, instead of a stiff clay, as indicated on the profiles. The depth of rock below the surface varied from 10 to 70 feet, and in order to build the dams more money and time would be required than had been estimated.

When this became evident, a careful examination of the canal route from Pedrò Miguel to the Pacific was undertaken, by wash and diamond drill borings and test pits, to ascertain if a more suitable place for the locks and dams could be found. In making these examinations care was taken to secure samples of the materials to be encountered at the various depths, as well as cores of the rock for depths of 25 feet below the foundation level of the lock walls.

A study of the data thus obtained led to the conclusion that one lock at Pedro Miguel and two at Miraflores offered the most economical and desirable solution. The advantages of this plan over the then existing project were that dams of lower height, less length, and resting on rock comparatively near the surface could be more easily constructed and could be completed at an earlier date; and finally that the locks in this location would be protected against all possibility of distant bombardment and would be less exposed to gunboat or torpedo boat attack. As a consequence, the commission recommended a change in the project, which received the approval of the President on December 19, 1907.

The designs for the locks are still in course of preparation but the studies have reached such a stage that the general features will be definitely determined at an early date. Satisfactory progress was

made in the design of the gates and the emergency dams and is reported on in Appendix F.

Gatun locks.—The borings previously made to determine the character of the foundation for the locks developed the existence of strata of varying materials, and investigations were continued during the year to ascertain the depths of the strata and to determine also whether suitable material extended sufficiently far below the level on which the lock walls are to be built to carry the weight; a depth of 50 feet below this level was fixed and the borings were so made. The materials encountered may be briefly summarized as a layer of argillaceous sandstone, overlying a layer of conglomerate which is composed of pebbles and other hard aggregates held together by a cementing material, and which subsequent excavation shows to be hard enough in texture to require blasting for its removal. Soft sandstone is next in order, consisting of sand with some cementing material, easily disintegrating under erosion. At the upper end volcanic tufa, with scattering pieces of argillaceous sandstone, is found, the proportion of tufa in this stratum diminishing toward the lower or north end of the site. Below this layer is dense argillaceous sandstone of considerable thickness.

The borings disclosed the presence of ground water, under pressure, in some of the conglomerate and through the stratum of soft sandstone, and investigations developed an underground flow through the sandstone, the source of supply being apparently ground water from the hills to the southeast and at a considerably higher elevation than the lock site. The indications are that the flow is about parallel to the axis of the lock. The volume of water encountered is small. There is no question that the various materials will bear the greatest loads that will be transmitted to them by the lock walls, if provision is made to prevent the underground flow of water through the softer materials on which part of the walls will rest.

It is intended now to prevent access to the foundation of this water by means of curtain walls connected with the underlying impervious stratum of argillaceous sandstone, and additional precautions will be taken if developments during construction make such advisable or necessary.

Appendix D, herewith, contains a report by the engineer who conducted the examinations and investigations of these foundations, together with maps illustrating the text, and for more detailed information attention is invited thereto.

The excavation for the locks was continued throughout the year, and nine shovels were assigned to this work. The total amount removed from the site was 1,769,115 cubic yards, of which 190,013 cubic yards were placed on the south toe of the dam, from the crossing of

the Chagres River to the temporary spillway; 69,432 cubic yards were deposited on the west side of the lock, making a fill for the operation of the construction plant, and the remainder was dumped as an embankment on the relocation of the Panama Railroad.

Draining the site, thus far, has been accomplished by gravity, but a sump has been prepared and a pumping plant ordered to take care of any water collecting in the pit from seepage and rains as the cut is deepened.

The broken stone required for concrete will be procured from Porto Bello, about 20 miles east of Colon. At that place a concrete dam has been built across El Mango Creek to impound water for drinking and other purposes, the gravel and sand for which were obtained from the harbor in the immediate vicinity; 5,052 cubic yards of concrete were used in the structure. A wharf, storehouse, office building, quarters, and barracks have been built and a sewer system installed. One steam shovel is at work and the quarry plant being erected.

Examinations of the coast were made with a view to locating suitable sand for concrete, and as a result of comparative tests it was decided to use the deposits in the vicinity of Nombre de Dios. Surveys were made and plans prepared for securing the sand from this locality.

Arrangements have been made for purchasing the necessary plant and marine equipment for constructing the locks and for handling the various classes of materials needed for the concrete.

Gatun dam.—Investigations, primarily undertaken to verify data already on hand concerning the character of material for the foundation of the dam, were continued for the purpose of determining more fully the character and extent of the various materials composing foundations for the dam and the spillway; for ascertaining whether there were any permeable connections between the swamp areas to the north and south of the site through the deposits in the gorges across which the dam will be built; for testing the ability of the material to support the proposed structure, and for learning whether suitable material for the dam can be had in the immediate vicinity. A test pit, 12 feet square, was sunk in the hill through which the spillway is being cut and near its head, and this has been carried down to about 35 feet below sea level. The rock formation here is practically the same as that at the lock site. On Gatun Island a test pit 20 feet square was sunk to a depth of 68 feet below sea level. Wash borings were resorted to, but care was taken to secure drive samples whenever there were indications of any change in the character of the material.

The examinations made of the spillway indicate that the rock is of sufficient strength to bear safely any of the loads that will be placed

upon it and that the principal water-bearing mediums are the fissures through the various strata, which allow the passage of water; this flow will be cut off, as in the case of the locks, by means of curtain walls properly constructed and connected with the impervious layer underlying the soft rock.

Both the test pit and the borings over the other portions of the dam site indicate that the top layer is a fine sand with a large proportion of clay intermixed. This extends to a maximum depth at one point of approximately 80 feet. Underlying this, for a distance of 100 feet or more, is a thick marine deposit of blue clay containing a little sand, and in some parts a considerable quantity of shells; this material is impervious. Under this and directly overlying the rock is a deposit, varying in thickness up to 20 feet, of small bowlders and gravel consolidated and cemented together with finely divided clays and silts. What seepage there is occurs in the top stratum; and though this is small, it is proposed to cut it off by sheet piling projecting up into the core of the dam and down into the impervious layer. The material encountered is of such character as to be amply strong for supporting the proposed structure. Examination by wash borings in the valleys above and below the site of the dam develops the fact that suitable material for dam construction can be readily procured by dredging and that the quantity available is amply sufficient for the purpose.

Two experimental dams, with dimensions corresponding to the dam as it is to be built, were made, on the scale of 1 inch to the foot; the first by depositing all material from the north side and allowing the water to drain south, by which the coarser material was deposited on the downstream side and the finer material on the upper side of the dam. This was tested for seepage under a full head of water, and the results are recorded in Appendix E herewith. Another dam to the same scale was constructed by depositing the material at the same time on both the upstream and downstream sides, allowing the finer material to deposit toward the center. These experiments show not only the suitability of the available material, but that a stable and water-tight dam can be built by hydraulic methods. A full description of the examinations and investigations, together with a discussion of the dam, is found in Appendix E.

Construction work at the dam during the year consisted in the removal of 918,920 cubic yards of material from the spillway. This channel is 300 feet wide, with a flare to 500 feet on the upstream side, and it was decided to maintain the elevation of its bottom at the south end at 10 feet above sea level, so as to preserve as thick a layer as possible of argillaceous sandstone over the conglomerate. The fill at the south toe was extended during the year across the French canal. In this toe 36,669 cubic yards of Bas Obispo rock were placed

and 329,257 cubic yards of material, largely rock, excavated from the spillway and the lock site. A trestle was also constructed along a portion of the north toe of the dam, from which 175,140 cubic yards of material from the spillway were dumped. Two lines of sheet piling have been driven across the Chagres River to form cofferdams to permit the pumping out of that portion of the stream to be occupied by the dam, in order to remove whatever unsuitable material has been left by the operation of the suction dredge over this area.

The old village of Gatun has been torn down and moved to a new site on the hills to the east.

Pacific locks and dams.—When the difficulties attending the construction of the Sosa-Corozal dam were encountered, and during the subsequent investigations, up to the date of approval of the project, work was reduced to a minimum, and consisted of stripping the quarry at La Boca, stone from which will be used for concrete in the construction of the locks, and of making a relatively low fill along the west toe of the site selected for the Sosa-Corozal dam to afford rail service between the quarry and the new lock site.

Pedro Miguel.—As it was more advisable and economical, the Culebra division excavated the lock site down to reference 40, practically completing it to this grade at the close of the fiscal year, and removed 1,071,696 cubic yards, which amount is included in the total yardage under the Culebra division. Operations on this site were begun by the locks and dams division in June, 1908, by the installation of one shovel at the lower end of the site and by the construction of railroad tracks connecting Pedro Miguel with Miraflores. This shovel moved a total of 7,493 cubic yards from the lock site. The lock is to be connected to the rock portion of an adjacent hill by prolonging the east wing wall. The west dam, 1,400 feet long, will be of earth, extending from the lock to a hill to the northwest; the top elevation will be at 107 and the top width, for purposes of estimating, is fixed at 40 feet, with side slopes of 4:1; as it will form a convenient dump for the Culebra division, its width will be considerably increased The maximum pressure will be due to a head of 40 feet, the average head being between 25 and 30 feet.

Miraflores locks and dams.—It is shown conclusively by test pits and borings that the locks will rest on rock of ample strength to make suitable foundations. A hard limestone is found for the upper part of the site, changing to argillaceous sandstone at the lower end. The borings disclosed no such variations in the formation as exist at Gatun.

The lock site was cleared and 2 steam shovels were installed in January, 1908, and additional shovels were added as the progress of work warranted. A total of 8 shovels was assigned to this division. The

number of cubic yards removed from the site amounted to 341,786, of which 297,476 cubic yards were from the prism of the locks. As the greater portion of this lock site is low ground, the excavated material was deposited on either side, to be used as foundations for the erecting plant, and across the lower end of the lock site for the construction of a levee. The pit is drained by gravity to a sump where a pump is installed to handle the water. The relatively large unit cost is due to the necessity of using the excavated material for specific purposes in a very contracted area, and the absence of rock, which makes the tracks under heavy rains very difficult of maintenance.

Examinations developed good foundations for concrete dams, and the one from the locks to Miraflores Hill, 750 feet in length, will be of this material. The Cocoli River crosses the lock site from the west and is a very formidable stream in times of heavy freshets, though the water runs off very rapidly. A diversion channel is being cut through the hills 1¼ miles west of the lock site, and a dam very nearly parallel with the axis of the locks, extending from the head of the locks to Cocoli Hill, is required to force the stream through this diversion, and must be a permanent structure. The west dam, at Miraflores, will be of earth, 2,300 feet long, heavily riprapped, 40 feet wide on top, the reference of which is 70, and side slopes of 4:1. The dam will be founded on impervious material and will be subjected to an average head of about 30 feet.

Mules and scrapers were used during the dry season for the diversion channel and 73,592 cubic yards were removed. Examinations made of rock formations in Cocoli and Miraflores hills, with a view to use in concrete, resulted in the selection of the Sosa Hill quarry as offering a better and more uniform quality of stone. Suitable sand for use in concrete has been located in ample quantities at Chame, about 20 miles west of La Boca, where a peninsular formation gives a protected harbor in which a dredge may operate at all seasons of the year.

River hydraulics.—The object of this division of the work and the stations maintained are noted in the last annual report. To these have been added during the year a flood warning station at Vigia.

Meteorology.—Three first-class and three second-class meteorological, and 13 rainfall stations are established and maintained for the use of the commission, and the information collected is furnished to other bureaus and associations. During the year fog observations were begun, and all work connected with tidal measurements was transferred to this division. A building has been constructed at Ancon for two seismographs and a meteorological observatory.

For further details relating to the work done by this department of construction, attention is invited to Appendix B.

MOTIVE POWER AND MACHINERY, MUNICIPAL ENGINEERING, AND BUILDING CONSTRUCTION.

Motive power and machinery.—The work of this division includes the erection, preparation for service, and maintenance in good repair of machinery necessary in canal construction; the erection and operation of air-compressor plants; electrical installations, and manufacture and repair work for other divisions. At the close of the year 2,206 men were carried on the rolls, and the expenditures amounted to $5,645,622.18. Three shops, located at Gorgona, Empire, and Paraiso, handle all work except electrical installations, and each is charged with the maintenance and operation of engine houses, coal chutes, and air-compressor plants in its territory.

Shop buildings have been erected at the three localities, those at Empire and Paraiso being completed during the year. With the completion of all authorized work, the Gorgona shops will have 307,000 square feet of floor space, the Empire shops 198,000 square feet, and the Paraiso shops 41,090 square feet. Included under the jurisdiction of the Gorgona shops is the engine house at Tabernilla for handling light repairs to engines overnight; under the jurisdiction of the Empire shops are engine houses at Las Cascadas, Lirio, and Rio Grande; the compressor plants at Las Cascadas, Empire, and Rio Grande, and the coal chute at Las Cascadas; under the jurisdiction of the Paraiso shops are an engine house, car-repair shed, and coal chute at Pedro Miguel.

At the Gorgona shops repairs are made to locomotives, unloaders, spreaders, and wooden car equipment, and such foundry and manufacturing work done as is necessary. Practically one-third of the output was manufactured material, including 4,279,237 pounds of gray-iron castings, 50,000 pounds of semisteel castings, and 216,947 pounds of brass and bronze castings. Gray-iron castings cost, for labor and material, $0.0359 per pound and brass castings $0.1951 per pound, including the cost of 1,462 patterns.

The Empire shops perform general repairs to steam shovels, steel car equipment, rock drills, and similar excavating machinery. Of the 101 steam shovels in service during the year, 55 were given general shop repairs, costing $145,479.41 for direct material and labor charges. As the steam-shovel excavation was 17,467,161 cubic yards, the cost of general shop repairs to steam shovels, per cubic yard, was $0.00833. The cost of field, or running repairs, to steam shovels, which, since December 1, 1907, were handled by the respective division engineers, was for the entire year $263,554.77, or $0.01509 per cubic yard for direct labor and material charges. At the air-compressor plants operated by these shops, 275,000,000 cubic feet of air were compressed per month, the cost in June, 1908, being $0.0344 per 1,000 cubic feet.

Light repairs to all classes of equipment at the southern end of the canal were handled at the Paraiso shop, heavy repairs being done at the Gorgona and Empire shops.

At the end of the year there had been erected and made ready for service the following equipment: One hundred and one steam shovels, 300 American and French locomotives, 3,451 American and 659 French cars, 20 cranes, 30 unloaders, 9 track shifters (manufactured on the Isthmus), 18 pile drivers (16 manufactured on the Isthmus), 23 bank or earth spreaders, and 46 unloading plows. Maintenance and repair of equipment by the mechanical division, including operation of air compressors, cost $1,951,618.79, and the cost of equipment purchased during the year, and other miscellaneous machinery, including erection, was $2,590,586.94.

Sixty-seven tests of machinery and equipment were made, which included the installation of oil-burning apparatus at various boiler plants. The boiler-inspection service inspected and tested 3,580 boilers.

During the year 13,365 16-candlepower electric lights were installed, which would supply this service to all commission settlements, except those to be flooded by Gatun Lake. Three automatic fire-alarm telegraph systems were also installed by the electrical subdivision during the year, and considerable other work of a like character was performed.

Municipal engineering.—The work of this division consisted of the completion of the waterworks, sewerage system, and paving in Panama and Colon, the cost of which is to be reimbursed to the United States through the collection of water rates in those cities, and of the construction of waterworks and sewerage systems, paving, grading, and road making in the Canal Zone. The total cost of the work done was $1,067,150.52.

Work in Panama and Colon, as originally planned, is practically completed and at the end of the year consisted of the following:

In Panama there were 60,469 feet of water pipe laid, 2,093 houses connected, 1,090 water meters tested and set, and 133 hydrants, 7 water cranes, 35 hose valves, and 1 venturi meter placed; 67,925 feet of sewer pipe laid, 1,019 houses connected, and 261 manholes and 227 catch basins constructed; 66,265 square yards of brick pavement, 19,116 square yards concrete pavement, and 3,572 square yards of macadam pavement laid, with 51,401 linear feet of concrete curb.

In Colon there were 69,280 feet of water pipe laid, 1,147 houses connected, 181 water meters tested and set, and 75 hydrants, 2 water cranes, 27 hose valves, and 1 venturi meter placed; 37,896 feet of sewer pipe laid, 264 houses connected, and 77 manholes and 77 catch basins constructed; 6,410 square yards of brick pavement and 62,621 square yards of macadam pavement laid, with 41,267 linear feet of

concrete curb and 1,923 linear feet of basket gutter. The sump into which all sewage flows was completed in certain minor details, and the D street canal, which takes care of a portion of Colon surface drainage, deepened, cleaned, and partially sheet piled.

The total cost of the above improvements in Panama is $1,018,387.27 and in Colon $894,275.17. The cost of improvements in Panama does not include the cost of the Rio Grande and Ancon reservoir and pipe line, which are situated in the Canal Zone and are to remain the property of the United States. To defray a proper proportion of the initial cost, $324,469.73, and maintenance of the latter works, a fixed rental is to be charged for water supplied to the city of Panama. The same procedure is to be followed in the case of the Mount Hope reservoir and accessory works, which supplies water to the city of Colon.

The maintenance of sewers, waterworks, and pavements in the cities of Panama and Colon was transferred to the division of public works, department of civil administration.

Further municipal improvements in Panama and Colon are necessary, as a sanitary measure, in certain outlying districts of these cities which have sprung up since American occupation, and the improvement of which was not contemplated in the original plans. The cost of this work, which will not be undertaken in the absence of any specific appropriation by Congress, is estimated to be $1,000,000.

In the Canal Zone there had been laid, up to June 30, 1908, in connection with the water supplies 462,951 feet of water pipe, to which 2,320 houses were connected, and 41 tanks, 2 railroad standpipes, 245 hydrants, 504 hose valves, 7 venturi meters, 36 small water meters, 117 public taps, and 13 water cranes installed. Water is supplied from 4 reservoirs and 2 pumping stations, the former located at Rio Grande, Camacho, Gorgona, and Brazos Brook, and the latter at Tabernilla and Gatun. In addition, as auxiliary and emergency units, 12 additional pumping plants are maintained on the Zone, 9 of which are continually in service and used to pump water for the higher levels of the different towns fed by the reservoirs.

The Rio Grande reservoir, which has a capacity of 496,670,000 gallons, supplies water to all points south of Culebra, including Panama, Ancon, and La Boca. The total annual consumption during the year was 942,200,000 gallons, of which the city of Panama used about three-tenths. At its lowest elevation during the year this reservoir contained 228,423,000 gallons. All water used in Panama and Ancon passes through a pressure filtration plant, having a daily capacity of 1,500,000 gallons, located at Ancon. In conjunction with the Rio Grande supply are operated the Ancon and Paraiso pumping stations, which furnish water for the higher levels at Ancon and Paraiso,

respectively, and the Cucaracha and Mount Zion pumping stations, which pump water for the higher levels at Culebra.

The Camacho reservoir has a capacity of 295,867,000 gallons and supplies the territory between Culebra and Bas Obispo. The annual consumption was 131,765,000 gallons. In conjunction with it are operated the Camacho and Bas Obispo pumping plants, the former pumping water for the higher levels at Empire, and the latter being held in reserve for use during periods of low water in the Camacho reservoir.

The Carabali reservoir, which is located back of Gorgona, has a capacity of 80,000,000 gallons, and furnished water to the territory between Matachin and Mamei. A plan is under consideration to increase the capacity of this reservoir to 153,000,000 gallons during the coming fiscal year. In connection with this reservoir are operated the Gorgona and Chagres River pumping stations, the former pumping water for the higher levels of Gorgona, and the latter supplying water from the Chagres River for boiler use at the Gorgona shops at low-water stages of the Carabali reservoir.

The Brazos Brook reservoir, which is located at Mount Hope, supplies the country from Mount Hope to and including Cristobal and Colon. The annual consumption of this reservoir, which has a capacity of 641,000,000 gallons, was 457,544,000 gallons. All water from this reservoir passes through a sedimentation basin and is filtered before being used. The Mount Hope and Mindi pumping stations are operated in conjunction with this reservoir, the former furnishing water to Cristobal and Colon, and the latter, during periods of low water in the reservoir, to the shipyard and railroad tanks at Cristobal and a part of Cristobal.

The Tabernilla pumping plant supplies water to the territory between San Pablo and Frijoles. During the year 500,000 gallons were pumped daily from the Frijoles River, This station also pumped 1,000 gallons of distilled water, condensed at this plant, to Tabernilla each day.

The Gatun pumping station is located on the Gatuncillo River, from which water is pumped to Gatun. One thousand two hundred gallons of distilled water, condensed at this plant, were also pumped to Gatun daily.

In order to afford additional fire protection to Ancon, Panama, and La Boca, a million-gallon reserve storage reservoir is to be constructed on Ancon Hill.

Surveys were made during the year of the valley drained by the Pedro Miguel River, in order to ascertain the supply which would be available for use in connection with the masonry work on the locks at Pedro Miguel and Miraflores. The lowest weir measurement dur-

ing the dry season showed a daily flow of 674,000 gallons, which it is believed will be ample for all needs.

Four fires during the year, two at Panama and two at Colon, demonstrated the efficiency of the water service. Wastage and leakage in water supplies were largely prevented through an effective water-inspection service.

Nearly 98 per cent of all quarters constructed by the commission have been connected with the Canal Zone sewerage systems, which, at the end of the year, consisted of the following: 217,975 feet of sewer pipe, 2,163 house connections, 254 manholes, and 12 catch-basins.

The construction of roads in the Canal Zone progressed to meet new conditions and to provide for new quarters and other buildings. At the end of the year the condition of road work in the Zone was as follows: 172,148 feet of macadam road built, 438 feet of brick on concrete bed constructed, and 18,133 feet of paths built.

In addition to the above, a system of waterworks and sewers was constructed, walks built, and a floating landing stage placed in position at Culebra Island, the new quarantine station in Panama Bay. Also considerable work in the line of municipal improvements was performed in native settlements, under the jurisdiction of the Canal Zone government, by which the cost of same was paid.

The Rio Grande rock crusher delivered 57,329 cubic yards of broken stone, at a cost of $1.75 per cubic yard.

At the end of the year 1,015 men were carried on the rolls of the division.

Systems of cost keeping were established and specific effort made toward securing the most economical results in performing work.

The total cost of municipal improvements in the Canal Zone has been, for waterworks and sewers, $2,358,840.44, and for roads, etc., $1,174,778.26.

Building construction.—During the year 505 new buildings were constructed; 1,147 American buildings repaired on account of deterioration, and additions or improvements made to 423 buildings; 1,178 old French buildings repaired on account of deterioration, and additions and improvements made to 275. The total expenditures for the year were $3,086,138.01, and the average number of men employed was 2,366. The average pay for skilled and unskilled labor per hour was, for gold men, $0.625, and for silver men $0.169. Of the total expenditures of this division for the year, $2,181,913.39 were spent in the construction of new buildings, the largest item of which was the construction of quarters for gold employees, which cost $982,771.86. The total cost of buildings constructed since American occupation to the end of the fiscal year has been $9,824,089.15, of which amount $421,882.64 have been spent for wire screening, with which all buildings are inclosed.

Among the more important items of construction performed during the year are the following: 33 hospital buildings, 37 storehouses, 7 fire-department houses, 9 laborers' bath houses, 26 laborers' range closets, 6 fumigation houses, 5 corrals, 9 schoolhouses, 5 commissaries, 1 clubhouse, 4 post-offices, 9 office buildings, 2 lodge halls, 18 standard laborers' barracks, 5 band stands, 2 Gallego mess halls, 5 hotels, 4 jails, 8 powder and detonator houses, 4 markets, 35 shop buildings, 8 laborers' washhouses, 3 bridges, and 200 type quarters for gold employees. There are 24 different types of living quarters for the accommodation of gold employees. The total number of buildings constructed since American occupation is 1,462, and the total number on hand is 3,313.

The Ancon wood and machine shop was operated during the year at a cost of $39,327.87 for labor, 70 men being employed.

At the Lirio planing mill, the principal manufacturing shop of this division, 58 men were employed at an annual cost of $55,880.59. All millwork for buildings is done at this shop.

At the Ancon stone crusher, operated to furnish stone for the masonry subdivision, 2,002 cubic yards of stone were crushed, at a cost of 88 cents per cubic yard.

At the cement block plant at Ancon 17,969 concrete blocks of various sizes were manufactured, at a cost of 12½ cents per cubic foot. These blocks were used in the construction of vaults, fire walls, powder and detonator houses and chimneys.

Attention was given to reducing the cost of work in this division by (1) modifying and cheapening the cost of all type structures through the elimination of unnecessary features, (2) the adoption of more suitable and more satisfactory materials and cheaper methods of application, and (3) requiring higher efficiency in the performance of work through comparison of detailed cost statistics on work done in the different districts. Economic building work was stimulated by a comparison of the cost of buildings erected by contract. The principal type of buildings constructed by the commission are now costing from 7½ to 9½ cents per cubic foot for bachelor quarters and from 11 to 13 cents for family quarters.

Further details in connection with the work of this department of construction are given in Appendix C.

SURVEYS.

A survey was made of the area to be flooded by the lake that under the old project would have been created by the Sosa-Corozal and Sosa-San Juan dams, the contours being carried to elevation 85.

Two original maps of the boundary survey showing the location of the monuments were prepared and submitted for action by the Republic of Panama.

The Mississippi River Commission, on request, kindly consented to the temporary transfer of two precise level men and outfits for the purpose of running a duplicate precise level line across the Isthmus. Special bench marks were designed, manufactured, and placed in position at points between the Atlantic and Pacific by two field parties. The precise level line is practically completed.

The projection of three general maps of the Isthmus, from data of all surveys so far made, was continued. At the close of the year the 1:12,000 map was practically completed, the 1:40,000 90 per cent completed, and the 1:100,000 map projected. To embrace the entire watershed of the Chagres extensive surveys of the upper valley will be necessary, and it is anticipated that this work will be accomplished during the current year.

CONSTRUCTION OF THE NEW PANAMA RAILROAD.

The relocation of the Panama Railroad is made necessary by the overflow of the existing roadbed on the completion of the lock type of canal. From the Atlantic terminal to Mindi, about 5 miles, and from Corozal to Panama and La Boca the old line will be used, but between Mindi and Corozal the road will be carried to the east of its present location and at the general elevation of 95, or 10 feet above the normal surface of the lake. As noted in the last annual report, a number of connecting tracks had been started from the operated line to the new location, and during July preparatory work went forward rapidly, but subsequent to this, due to lack of funds, construction work of a general character was shut down and confined to such sections as would materially aid in canal construction.

The old roadbed crosses the site to be occupied by the Gatun dam, and in order not to delay work on this structure it was necessary to transfer the road to a new location east of the locks. The work was pushed, and the new line from Mindi to Tiger Hill, a distance of 4½ miles, is now in operation.

A number of valleys north of the Chagres River require heavy embankments, the material for which can best be obtained from the Culebra division. To utilize the dumps along the new line arrangements were made for the erection of a bridge across the Chagres River, near Gamboa, 1,320 feet in length. Concrete piers and abutments were built, the material was received, and the bridge constructed. To reach the dumps north of Gamboa approximately 2 miles of the relocated line were completed.

The construction of Miraflores tunnel was continued because the nature of the material was to a certain extent unknown, and part of it gave indications, subsequently verified, of being very treacherous. The work has advanced sufficiently to permit the laying of concrete for the lining.

Two concrete arched culverts were constructed, one for the flow of the Pedro Miguel River and the other for the Caimitillo River, for the embankments on which the new line is located south of Pedro Miguel.

In addition to the work of the relocation, the commission paid for the completion of the double tracking necessary for the transportation of earth and stone required for the elevation of the track 3 feet where it crosses the spillway of the Rio Grande reservoir, so as to increase its storage capacity, and for changing the viaduct which crosses the canal prism from its location at Pedro Miguel to Paraiso, the former interfering with the construction of the locks, and it furnished three new spans for the Barbacoas Bridge.

The change in the location of the locks from La Boca to Miraflores saved the construction of a new line from the Cardenas River to La Boca, as well as the erection of new wharves. Subsequent examinations of the Gatuncillo bottom led to surveys with a view to avoiding the heavy embankments through the completed lake, and a new line has been tentatively selected pending further preliminary surveys.

Construction work for the new line and on the operated line was done by the Panama Railroad Company. For further details attention is invited to Appendix G.

COST KEEPING.

Beginning July 1, 1907, a system of engineering cost keeping was established, and monthly statements are prepared showing the cost of each principal piece of work. The cost is kept under two general heads, from division engineers' monthly reports and sundry general items. The first includes all expenditures pertaining to the work under the division engineers and furnishes a basis for comparing the relative cost of current work; the second embraces general expenditures, including general expenses of the commission, disbursing officer, examiner of accounts, labor, quarters and subsistence, material and supplies, and miscellaneous expenditures on the Isthmus, such as transportation, travel expenses, telegraph, and stationery. There are excepted from these expenditures, however, all charges of civil administration, sanitation, and municipal improvements, such as waterworks, sewers, and roads within the limits of the zone. These expenditures are excluded because they are not useful in a comparative statement of the work proper, although necessary to the construction of the canal as a whole, and because they were not incorporated in the estimates of the minority members of the consulting board, whose plans are being executed.

Tables showing the results for the fiscal year 1907–8 are hereto appended, marked "H."

The cost of plant is not included for the reason that all plant necessary to complete the canal has not yet been acquired, so that an equitable distribution of this item can not be made. It includes building construction, other than for the departments of civil administration and sanitation, rolling stock, excavating machinery, floating equipment, shops, shop machinery and tools, railroad ties, rails and fastenings, land purchased, docks and wharves, Panama Railroad second track, relocation of the Panama Railroad, construction of electric-light plants, construction plant for quarries, and locks and dams. It was deemed best to make this statement in this way for the time being rather than to assign an arbitrary figure which might be misleading. The monthly cost of each piece of work, as shown on the accompanying tables, balances with the amount charged to the same work on the books of the disbursing office.

MATERIAL AND SUPPLIES.

The division of material and supplies is charged with the purchase and handling on the Isthmus of all material needed in connection with the construction of the canal. Special classes of material and supplies are purchased on requisitions by the purchasing department of the commission in the United States; the stock of other material is replenished as the rate of consumption at the various storehouses along the line dictates. This division is also charged with the care and maintenance of local transportation and the operation of the commission printing plant, and of a typewriter repair shop. Local purchases on the Isthmus consist of materials and supplies which are not carried in stock and which are urgently needed; they embrace largely the purchase of supplies for engineering parties, the subsistence department, and the hospitals.

Stock material for general use is distributed from 9 storehouses located at the more important points along the line, in which are stored those classes of materials and supplies which are most in demand in the territory fed by each.

During the fiscal year this division received material valued at $11,607,094.63 and disbursed material to a value of $11,685,158.33. Of the material issued, $182,894.56 cover old French material utilized or disposed of during the year, including scrap brass, copper, and cast iron used in the foundries at the Gorgona shops.

Some of the more important items of equipment received were: Thirty-eight steam shovels, 800 cars, 10 unloaders, 10 spreaders, 6 ballast plows, 9 cranes, 8 dredges, 5 tugboats, 12 steel barges, 2 air-compressor plants, 172 rock drills, 13 rock channelers, 508,000 pounds track bolts, 1,684,000 pounds track spikes, 119,150 pounds angle bars, 470,000 tie plates, 481 15-foot split switches, 628 frogs, 15 oil fuel

tanks, 2 launches, 4 concrete mixers, 1 road roller, 3 motor cars, 1 material-handling plant, 1 15-ton rock crusher, 4 saddle-tank locomotives, 19,254½ tons of steel rails, 501,876 ties, 3 electric cranes, 18 hoisting engines, 38,985,521 feet b. m. of lumber, 34,657 piles, 501,574 switch and cross ties, 246,000 brick, 8,852,000 pounds dynamite, and 54,000 pounds blasting powder.

During the year the rebuilding of the large general storehouse at Mount Hope was completed and the building restocked. New storehouses were built at Bas Obispo, Empire, Culebra, and Paraiso, and new oil houses at Mount Hope, Gorgona, Bas Obispo, and Empire. In addition the construction was authorized of two storage magazines for dynamite, of 300 tons capacity, and two magazines for the storage of electric exploders, blasting caps, and fuses, with the necessary watchmen houses adjacent thereto. One set of buildings is to be located in the Mindi Hills and the other on the Chagres River above Gamboa.

Local transportation is handled at 16 corrals, accommodating 632 animals. The commission owns 397 vehicles, of which 163 are wagons, 119 carts, 25 carriages, 8 wagonettes, 8 ambulances, 54 scrapers, and 20 miscellaneous.

The stationery and printing plant supplies all the stationery and printing required by the commission on the Isthmus. A complete stock of standard stationery is carried as well as special supplies for the engineering department. The printing plant consists of 14 presses and was operated to its full capacity throughout the year. About 30,513,497 pieces of printing matter were turned out, at a cost of $38,513.10. Stationery and engineering supplies were issued to a value of $32,758.

Twelve hundred and twenty men have been carried on the rolls of this division during the year, at a total annual cost of $665,126.07.

Detailed information as to the work of this division may be secured by reference to Appendix I.

LABOR, QUARTERS, AND SUBSISTENCE.

This department is charged with securing all skilled and unskilled labor, supplies for and custody of quarters, and the operation of hotels, messes, and kitchens.

On the resignation of Mr. Jackson Smith, Maj. Carrol A. Devol, quartermaster, U. S. Army, was assigned to duty under the commission, and in the reorganization of the work the duties of this department are to be divided. To Major Devol will be assigned such of the duties of the old department as relate to labor and quarters, and there will also be added the duties of the present division of material and supplies, with the work of which his professional experience in connection with the Quartermaster's Department of the Army has thoroughly familiarized him. The resulting department will be designated the "quartermaster's department."

The subsistence feature will be consolidated with the commissaries of the Panama Railroad and operated as the subsistence department of the commission, in charge of Maj. Eugene T. Wilson, Artillery Corps, U. S. Army.

The separation of the department into these two departments has been effected, but all the details of the organization scheme are not yet complete.

Labor.—A net decrease in the skilled force was made during the year, yet there were almost as many new employees as in the preceding year, the number of men employed being 5,200 and 5,800, respectively, for the two years, indicating the shifting character of the force and showing that it is practically renewed every year. A radical change, however, has taken place in the source of supply. There were 1,828 men employed in the United States, as against 3,038 the year before, while the number employed on the Isthmus has increased from 2,780 to 3,382.

There are approximately 500 more Europeans and 1,000 more West Indians on the work than there were at the close of the previous fiscal year. To cover this increase and to fill vacancies caused by the departure of employees from the Isthmus 4,150 West Indians and 3,650 Europeans were imported. As the total excess of immigration over emigration was nearly 18,000, the labor problem may be considered as solved.

Quarters.—Approximately 700 American families were brought to the Isthmus during the year and quarters accommodating 250 families were recommended for construction. While there are a number of applications for quarters pending, there is no such congestion for married quarters as existed a year ago.

Laborers' quarters are at present ample and there is an increasing tendency among certain classes of laborers to go to the bush, or into tenements in various small towns along the Zone. While relieving the commission of the obligation to quarter them, it is an open question whether the move has been beneficial.

Subsistence.—At the close of the year 20 hotels were operated for Americans, 25 mess halls for Europeans, and 31 kitchens for West Indian laborers. A system of inspection was instituted during the year and an attempt made to improve the cleanliness of all classes of messes and to improve food supplies.

For further details as to the work of this department attention is invited to Appendix J.

ZONE GOVERNMENT.

The organization of this department, as outlined in previous annual reports, remained unchanged during the year. The executive branch includes the executive office; the division of posts, customs, and rev-

enues; police and prisons; schools; fire protection; public works, and the office of the prosecuting attorney. The judicial branch includes the supreme, circuit, and district courts of the Canal Zone. The head of this department also represents the commission in its relations with the Republic of Panama and foreign representatives accredited to Panama.

The relations of the commission with the Republic of Panama and foreign representatives are satisfactory. A number of questions growing out of the provisions of the treaty or subsequent agreements, or arising from the proximity of the Zone and Panama, were settled satisfactorily, and the officials of the Republic have manifested at all times a desire to aid the work of the commission.

Congressional legislation affecting the Canal Zone includes the provision respecting the use of local revenues of the Zone, the employers' liability act, and the act providing for compensation of government employees injured in the performance of duty. By executive order, the Chinese-exclusion law of the Government of Panama was extended to the Canal Zone, and trial by jury provided for criminal prosecutions wherein the penalty of death or imprisonment for life might be inflicted. Ordinances prescribing building regulations, providing for the impounding of stray animals, and revising the liquor regulations and the schedule of general taxes and license fees collected in the Canal Zone were enacted by the commission and approved by the Secretary of War.

Posts, customs, and revenues.—The sale of postage stamps amounted to $72,708.67, an increase of 32 per cent over the previous year, with a corresponding increase in the volume of mail handled. Letters and parcels to the number of 42,089 were registered, of which about 45 per cent was official business. In November, 1907, postal clerks were placed on the Panama Railroad steamers between New York and Colon to expedite the handling of mail to and from the United States. Money orders of a value of $4,686,684.98 were issued, yielding a revenue of $19,309.14. This is an increase of more than 100 per cent over the money-order business of the preceding year. New post-office buildings were erected at Cristobal, Culebra, and Ancon.

At the ports of Ancon and Cristobal 412 vessels entered, aggregating 817,863 tons. The usual services were rendered seamen and vessels. No duties or customs fees were collected.

On June 30, 1908, there were 1,081 leases in force, covering building lots, buildings, and agricultural lands, from which the revenue derived was $17,436.76, or over 100 per cent more than during the previous year. On account of distillation tax, liquor licenses, and fees from bonding company qualified to do business in the Canal Zone $44,743.96 were collected. The general tax and license receipts were $77,467.47.

During the year 32 estates, involving personal value of not over $500 each, were settled, and 16 remain to be adjusted. The total money handled on this account during the year amounted to $6,025.75.

Miscellaneous collections made by this division for other departments of the commission amounted to $22,054.24. The total revenues collected aggregated $231,666.87, and moneys handled $4,946,431.84.

Police and prisons.—At the close of the year the police force consisted of 232 men. There were 6,075 arrests and 4,731 convictions, and of the latter 4,633 were for misdemeanors and 98 for felony. At the close of the year 108 felony convicts were in the penitentiary and 72 had been discharged. Prisoners were employed on public improvements, such as the construction and repair of roads and streets, and accomplished work to the value of $14,856.65, computed on a basis of 10 cents per hour. The cost of guarding, subsisting, and clothing prisoners so employed was $20,779.78.

In civil cases 1,540 writs of process were served by the chief of police in his capacity as marshal. He is also warden of the penitentiary and coroner of the Canal Zone, in which latter capacity he investigated 140 deaths.

Schools.—Schools were maintained for white children at 11 places, and for colored children at 15 places, along the line of the canal. In the former 721 pupils were enrolled and in the latter 2,146. New school buildings were completed at Ancon, Paraiso, Culebra, Empire (2), Las Cascadas, Bas Obispo, Gatun, Cristobal, and Colon Beach.

Fire protection.—Paid fire companies were organized and installed at Gorgona, Empire, Culebra, and Ancon. Each company consists of 4 men and is provided with a hose wagon equipped with extension ladder, straight roof ladder, and 1,000 feet of hose. There is also a paid fire company at Cristobal, and 18 volunteer companies, equipped with hose reels and hose, located at various points along the line. Electric fire-alarm systems were installed at Gorgona, Empire, Culebra, and Ancon. For the protection of docks at Cristobal, Colon, and La Boca two tugs were equipped with fire pumps and hose. There were 63 alarms of fire in government property valued at $1,097,619.46, and the total loss was $46,170.50. The companies at Cristobal and Ancon cooperate with the Colon and Panama firemen in protecting property in those cities.

Public works.—On June 30, 1908, there were 1,189 water connections in Panama and 318 in Colon, exclusive of commission and Panama Railroad connections. The charge for water furnished the city of Panama is 30 cents per 1,000 gallons, with 5 per cent discount for payment in fifteen days from end of quarter, and in Colon 50 cents per 1,000 gallons, with a discount of 10 per cent. The collections from private consumers in Panama were $42,568.25 and in Colon

$25,233.90. In Panama the per capita daily consumption was 12.98 gallons, and the average annual cost per connection was $51.93; in Colon the per capita daily consumption was 53 gallons, and the annual charge per private connection $119.05. At the close of the year there were 75 private connections to the Zone water systems, on account of which collections amounted to $2,772.37.

New public markets were constructed at Pedro Miguel, Paraiso, Culebra, Las Cascadas, and Tabernilla, which, with the markets at Empire, Gorgona, and Cristobal, made eight in operation.

Prosecuting attorney.—Information was filed in the circuit courts by the prosecuting attorney against 366 persons, of whom 192 were convicted. The general civil legal business of the commission is handled under the direction of the general counsel in the legal department.

Courts.—The supreme court held 17 sessions during the year, acting on eleven decisions of the circuit courts in 4 criminal and 7 civil cases.

In the circuit courts criminal cases were filed against 366 persons, of whom 192 were convicted and 56 acquitted. Twenty-four cases were still pending and the balance have been dismissed. Sixty-five civil cases were disposed of, out of a total of 111 on the docket.

In the district courts criminal cases were filed against 5,776 persons, of which all but 25 had been acted on at the close of the year. Fourteen civil cases were pending at the end of the year, of the 433 which had been filed.

Canal Zone funds.—At the beginning of the fiscal year there were $144,358.09 in the Zone treasury; $283,906.17 were collected during the year and $183,501.95 expended, leaving a balance on hand at the close of the year of $244,762.31. Of the money expended, $47,175.03 were for public works and improvements in the Zone, $35,749.47 for the maintenance of public schools, $99,673.21 for the maintenance of the postal service, and $904.24 for contingent and miscellaneous expenses.

For further details of the work of this department see Appendix K.

SANITATION.

The work of this department is twofold; it is charged with general sanitary work of the Zone, as well as of the cities of Panama and Colon, which includes the collection of garbage, the removal of night soil, fumigation, disinfecting, cleaning of streets, draining and filling swamps, cutting of grass and removal of vegetation, minor repairs to screening, and ditching and tiling work for drainage; also the care of the sick and the maintenance of the hospitals.

As the work of construction expanded, the work of sanitation correspondingly increased by reason of the establishment of new settle-

ments. During the year, on this account, work in the vicinity of Caimito, Santa Cruz, and Porto Bello, was added, and that at San Pablo and Matachin was increased. The general health conditions are indicative of the success obtained.

General health conditions depend upon proper policing of quarters, securing and maintaining a wholesome water supply, and good sewerage, as well as such sanitary work as is outlined above. The present quartermaster's department is charged with the care of quarters and general policing; the engineering department is charged with water supply and sewerage, and the sanitation department maintains a tiling gang and ditching gang. The quartermaster's department must maintain gangs for policing and grass cutting in connection therewith in the same territory that the sanitation department has its force of laborers on sanitary work; either department is fully equipped to do the work of the other. Although the end in each case is the same—the general bettering of health conditions—the objects sought are to some extent different, in that the sanitary work is undertaken to reduce the breeding places of malarial and yellow-fever mosquitoes. After careful consideration it was concluded that economy would result, friction be removed, and responsibility definitely fixed if, in addition to the work of policing and grass cutting in the vicinity of quarters, the quartermaster's department gangs were charged with the collection of garbage, the removal of night soil, and the cutting of grass and brush for the sanitation department, and if the tiling and drainage were carried on by the construction forces of the engineering department. With the approval and consent of the chief sanitary officer, the transfer of these duties will be made effective September 1, and in order that no impairment of sanitary conditions may result, the quartermaster's department is to perform such grass and brush cutting as may be designated by the various sanitary inspectors, and the division engineers are to drain such areas as the chief sanitary officer may prescribe, in accordance with plans and upon data furnished by him.

If, with the shifting character of the population, the death and sick rate can be taken as a criterion for general health conditions, they have been considerably improved, for with an average of 43,057 names on the pay rolls the death rate per thousand was 18.32, less than half that of the previous year. For the white force, taken at an average of 12,058, given by the pay rolls, the rate was 15.34 per thousand, and with a force of blacks averaged at 30,999, the death rate was 19.48 per thousand, less than half that of the previous year. The large decrease in the death rate among the blacks is attributed to better sanitation, but, primarily, according to the statements of the doctors, to the better food, enabling them to offer greater resistance to disease.

At the beginning of the year 1,139 patients remained in the hospitals, and during the year 27,523 were admitted for treatment; of this number 929 died, 1,138 were still undergoing treatment at the close of the year, and the balance were discharged.

The two hospitals at Ancon and Colon at present care for most of the sick. About 20 sick camps along the line care for the slightly sick, and the more seriously ill who are waiting for the hospital train to take them to the terminal hospitals. The old building at Culebra was converted into a hospital for penitentiary patients, though still used as a sick camp for that station.

For further details see Appendix L.

DISBURSING OFFICE.

At the beginning of the fiscal year this office had charge of time inspection, preparation of pay rolls, vouchers, issuance of commissary and hotel books, and the disbursements of moneys on the Isthmus. Under executive order of August 15, 1907, reorganizing the accounting methods of the commission, the duties of time inspection were assigned to the examiner of accounts, and that of keeping the property records and general books of the commission was transferred to the disbursing office.

Several changes in the organization were made in the interests of economy; the more important were the substitution of monthly payments to all employees, laborers formerly being paid semimonthly; preparation and checking of pay rolls in division offices instead of in the disbursing office; and the elimination of duplicate property records in the division of material and supplies, this record now being kept by a force from the disbursing office located in the office of the chief of the division of material and supplies.

During the year, disbursements on the pay rolls of the commission amounted to $18,062,000, the average payment per month to employees on the gold roll being $125.80, and on the silver roll about $40 gold per month.

For further details of this office see Appendix M.

EXAMINATION OF ACCOUNTS.

This department was created by executive order of August 15, 1907, when the positions of general auditor and local auditor were abolished. Its duties embrace the administrative examination of the disbursing officer's accounts, before their transmission to the Auditor for the War Department; the inspection of the accounts of all officials of the commission, on the Isthmus, charged with the care of funds or property; time inspection, by which the time books in the hands of the timekeepers and foremen engaged upon the work of all depart-

ments is checked; and checking collections made by the disbursing officer from the record of claims payable to the commission.

The examiner of accounts, in addition to the work outlined above, is also auditor for the Canal Zone.

The work done by the department during the year is outlined in Appendix N, which contains a statement of receipts and expenditures of Canal Zone funds, as required by existing law.

COMMISSARY.

Under the reorganization already effected, the commissary is operated by the subsistence officer of the commission, under the direction of the president of the Panama Railroad.

Through its 13 branch stores, located at the more important points along the line of work, the commissary supplies ice, meats, bread, pies, cakes, ice cream, and groceries of all kinds, as well as laundry service, to the hotels, messes, and kitchens, and to employees of the commission. The value of the commodities sold during the year aggregated $3,736,607.11. Of the branch commissaries, five were constructed since the last report, at East La Boca, Rio Grande, Culebra, Empire, and Las Cascadas. In addition, coffee-roasting, ice-cream, and pie and cake baking plants were added to the equipment of the main commissary at Cristobal.

An average of 742 employees were carried on the rolls of this department, at an annual cost of $430,343.75.

RECREATION FOR EMPLOYEES.

During the year type lodge and church buildings were constructed at Paraiso and Gorgona, and 5 band stands erected, one each at Ancon, Paraiso, Las Cascadas, Bas Obispo, and Cristobal. In the church and lodge buildings religious services are held on the lower floor and meetings of secret orders and societies on the upper floor. The band maintained by the commission plays every Sunday afternoon at some locality on the line.

The four commission clubhouses, located at Culebra, Empire, Gorgona, and Cristobal, operated under the management of the Young Men's Christian Association, were very successful in the accomplishment of the work for which constructed, and it is believed that an equal number should be built at other important points.

Further details of the operation of these clubhouses are given in Appendix O.

MONEY STATEMENT.

Appropriations.

June 28, 1902:			
Canal connecting Atlantic and Pacific oceans		$10,000,000.00	
Dec. 21, 1905:			
Canal connecting Atlantic and Pacific oceans		11,000,000.00	
Feb. 27, 1906:			
Material purchases in United States		1,000,000.00	
Miscellaneous expenses on Isthmus		400,000.00	
Panama Railroad and second main track		200,000.00	
Isthmus pay rolls		2,100,000.00	
Salaries and incidental expenses in United States		75,000.00	
Equipment purchases		1,565,786.00	
Reequipment of Panama Railroad		650,000.00	
Total available appropriations to June 30, 1906			$26,990,786.00
June 30, 1906:			
Expenses in United States		$368,242.69	
Salaries	$251,063.33		
Incidental expenses	117,179.36		
Construction, engineering, and administration		21,018,537.24	
Pay of officers and employees	$2,600,512.00		
Pay of skilled and unskilled labor	8,650,661.00		
Material purchases	9,032,814.24		
Incidental expenses on Isthmus	734,550.00		
Civil administration		968,200.00	
Pay of officers and employees	600,000.00		
Pay of skilled and unskilled labor	50,000.00		
Material and incidental expenses	318,200.00		
Sanitation and hospitals		2,101,435.15	
Pay of officers and employees	600,000.00		
Pay of skilled and unskilled labor	679,068.00		
Material and incidental expenses	822,367.15		
Reequipment of Panama Railroad		1,000,000.00	
Total appropriations, year 1907			25,456,415.08
Mar. 4, 1907:			
Expenses in United States		253,000.00	
Salaries	$184,000.00		
Incidental expenses	69,000.00		

Mar. 4, 1907—Continued.			
Construction, engineering, and administration		$20,366,000.00	
Pay, officers and employees	$2,772,000.00		
Pay, skilled and unskilled labor	7,990,000.00		
Material purchases	9,046,000.00		
Incidental expenses on Isthmus	558,000.00		
Civil administration		825,000.00	
Pay, officers and employees	486,000.00		
Pay, skilled and unskilled labor	50,000.00		
Material and incidental expenses	289,000.00		
Sanitation and hospitals		2,034,000.00	
Pay, officers and employees	766,000.00		
Pay, skilled and unskilled labor	468,000.00		
Material and incidental expenses	800,000.00		
Reequipment Panama Railroad		1,385,000.00	
Redemption Panama Railroad Co. bonds		2,298,367.50	
Feb. 15, 1908:			
Expenses in the United States		18,600.00	
Salaries	$18,600.00		
Construction, engineering, and administration		11,990,400.00	
Pay, officers and employees	$210,700.00		
Pay, skilled and unskilled labor	5,536,300.00		
Material purchases	6,085,700.00		
Incidental expenses on Isthmus	157,700.00		
Sanitation and hospitals		169,900.00	
Pay, skilled and unskilled labor	169,900.00		
Total appropriations, year 1908			$39,340,267.50
May 27, 1908:			
Expenses in the United States		176,000.00	
Salaries	$149,000.00		
Incidental expenses	27,000.00		
Construction, engineering, and administration		23,450,000.00	
Pay, officers and employees	$3,400,000.00		
Pay, skilled and unskilled labor	8,400,000.00		
Material purchases	11,250,000.00		
Incidental expenses on Isthmus	400,000.00		

May 27, 1908—Continued.			
Civil administration		$241,000.00	
Pay, officers and employees	$225,000.00		
Pay, skilled and unskilled labor	16,000.00		
Sanitation and hospitals		1,575,000.00	
Pay, officers and employees	700,000.00		
Pay, skilled and unskilled labor	500,000.00		
Material and incidental expenses	375,000.00		
Reequipment Panama Railroad		1,100,000.00	
Relocation Panama Railroad		1,085,000.00	
For purchase of two steamers		1,550,000.00	
Total appropriations, 1909			$29,177,000.00
Total appropriations			120,964,468.58

Expenditures.

Construction of canal		$57,357,346.47	
Buildings		8,549,668.90	
Panama waterworks and sewers		1,342,857.00	
Colon waterworks, sewers, and paving		894,275.17	
Settlements with Panama Railroad Company and others in suspense		221,172.72	
Total, construction and engineering			$68,365,320.26
Government of the Canal Zone		2,146,996.77	
Buildings		437,121.21	
Zone highways		1,174,778.26	
Total, civil government			3,758,896.24
Sanitation and hospitals		7,171,315.46	
Buildings		837,299.04	
Total, sanitation and hospitals			8,008,614.50
Loans to Panama Railroad Co			4,374,310.54
Purchase of Panama Railroad stock			157,118.24
Purchase of real estate outside of canal construction			59,433.36
Balance due by laborers for their transportation			31,728.61
Services rendered and material sold individuals and companies			2,327,343.24
Total			87,082,764.99
Less:			
Amount unpaid on pay rolls		$1,678,417.72	
June, 1908, rolls	$1,487,780.88		
Prior months	190,636.84		
Value of material received from the New Panama Canal Co. and used in work or sold included in above and credited to purchase price of canal		831,348.72	
			2,509,766.44
Total expenditures			84,572,998.55
Balance available July 1, 1908			36,391,470.03
Total			120,964,468.58

WASHINGTON OFFICE.

Under the executive order of August 15, 1907, the purchase of materials and supplies was placed under the supervision of the Chief of Engineers, U. S. Army, who was authorized to maintain a purchasing department in the office of the Isthmian Canal Commission, in Washington. The following divisions of work were established under the direction of the general purchasing officer, who also acts as chief of office: General office, general counsel, disbursing office, assistant examiner of accounts; appointment, correspondence, and record divisions, and purchasing department. A part of the inspecting engineer's office was transferred from New York to Washington.

During the year 2,160 persons in the United States were tendered appointments on the Isthmus, covering 154 different positions, and 1,947 accepted; and 5,397 persons were provided with transportation from the United States to the Isthmus.

During the year the disbursing officer in the United States paid 10,956 claims, having a value of $13,728,288.51.

The purchase of all supplies and materials for commission use is under the supervision of the general purchasing officer in Washington (assigned for this duty from the Engineer Corps, U. S. Army), with assistant purchasing and shipping agents in New York, New Orleans, and San Francisco. A similar office at Tacoma, Wash., was discontinued on June 30, and the work taken over by the United States engineer office at Seattle and the Washington office. Circular invitations for bids are prepared from requisitions received from the Isthmus and distributed throughout the country; the practice of allowing bids to cover delivery of materials on the Isthmus has given all sections equal opportunity in submitting proposals.

Details of the work of the office are given in Appendix P.

Respectfully submitted.

GEO. W. GOETHALS,
Lieutenant-Colonel, Corps of Engineers, U. S. Army,
Chairman and Chief Engineer.

HON. LUKE E. WRIGHT,
Secretary of War, Washington, D. C.

APPENDIX A.

REPORT OF MAJ. D. D. GAILLARD, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, HEAD OF THE DEPARTMENT OF EXCAVATION AND DREDGING.

CULEBRA, CANAL ZONE, *July 21, 1908.*

SIR: I have the honor to submit the following report of operations in the department of excavation and dredging for the fiscal year ending June 30, 1908:

This department embraces the Culebra division, Chagres division, Colon dredging division, and La Boca dredging division.

The total amount of material removed during the fiscal year in the department of excavation and dredging is given in the following table:

	Cubic yards.
Culebra division	12,065,138
Chagres division	1,774,124
Colon dredging division	5,624,582
La Boca dredging division	5,328,859
Total	24,792,703

The details of the work accomplished in each division are given in what follows:

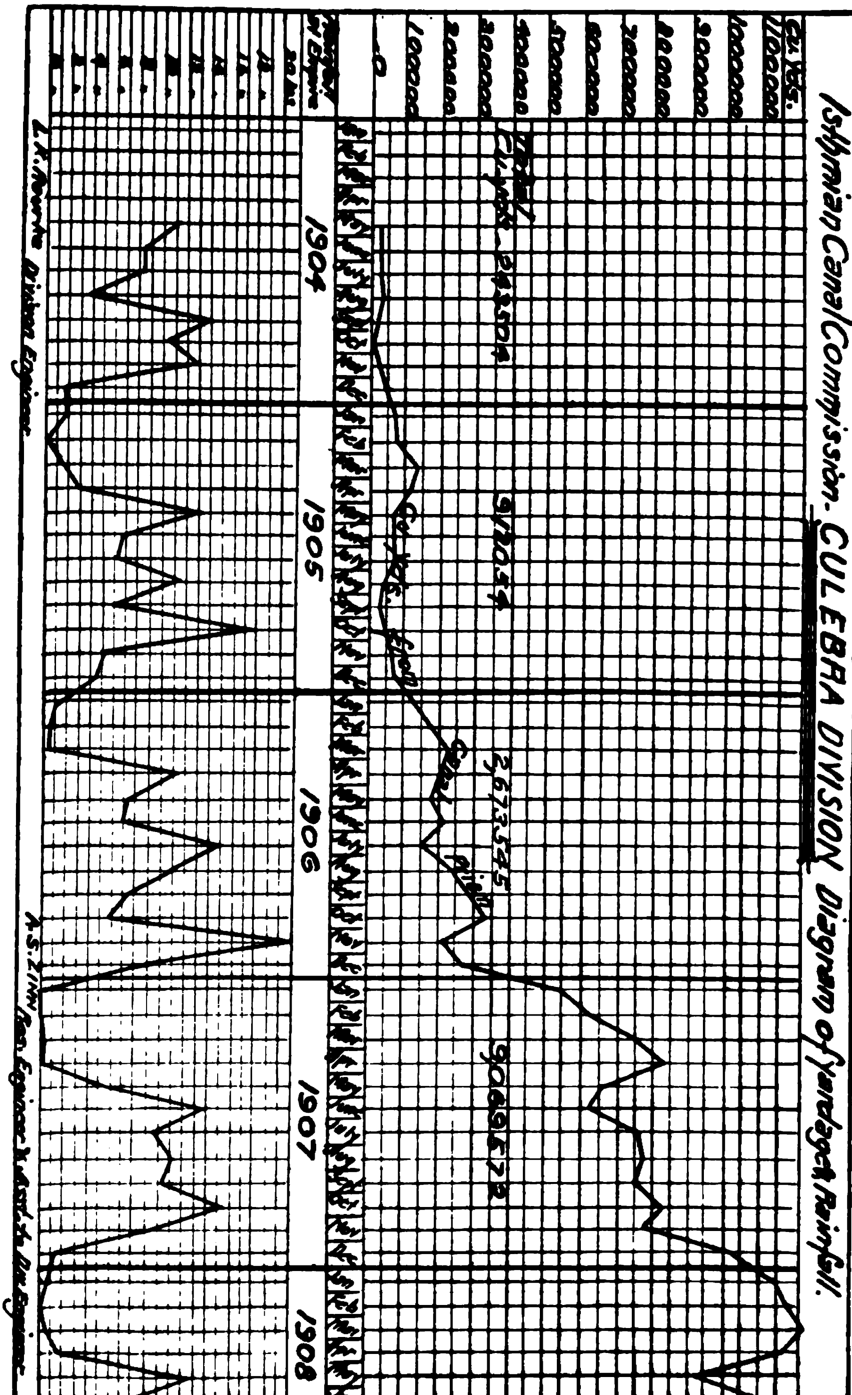
CULEBRA DIVISION.

This division extends from the point where the canal first crosses the Chagres, in the vicinity of Gamboa, to the south end of the lock site at Pedro Miguel, a total distance of 9.2 miles.

The total amount of material excavated in the Culebra division for the fiscal years ending June 30, 1904, 1905, 1906, 1907, and 1908, is given in the following table:

Fiscal year ending June 30.	From canal prism.				Total excavation, including canal prism and accessory works.			
	Earth.	Rock.	Not classified.	Total.	Earth.	Rock.	Not classified.	Total.
	Cu. yds.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
1904			60,107	60,107			60,107	60,107
1905	327,404	230,875	183,365	741,644	327,404	230,875	183,365	741,644
1906	764,327	742,235		1,506,562	764,327	742,235		1,506,562
1907	2,288,199	3,282,233		5,570,432	2,413,358	3,325,613	29,043	5,768,014
1908	3,859,189	7,826,115		11,685,254	4,163,435	7,901,703		12,065,138
Total	7,239,069	12,061,458	243,472	19,563,999	7,668,524	12,200,426	272,515	20,141,465

The amount of material removed during each month since the United States assumed control in May, 1904, is shown graphically on the accompanying plate:


Isthmian Canal Commission. CULEBRA DIVISION. Diagram of Yardage & Rainfall.
1904
1905
1906
1907
1908
Cu. Yds.
L. K. Rourke Division Engineer
A. S. Zinn Res. Engineer & Asst. to Div. Engineer

It is interesting to note the gradual increase in the amount of work done, but in considering the plate and tables it must be remembered that previous to January 1, 1907, much of the work was of a preparatory nature and consequently the output was necessarily less than when the shovels had been established on a regular working basis. Moreover, the average number of steam shovels has gradually increased from 20 in the first part of the last fiscal year to 41 for the fiscal year ending June 30, 1908.

The following table shows the amount of material excavated monthly in the Culebra division during the fiscal year ending June 30, 1908 (place measurement):

Month.	From canal prism.			Total excavation, including canal prism and accessory works.		
	Earth.	Rock.	Total.	Earth.	Rock.	Total.
1907.						
July	232,520	538,050	770,570	232,520	538,050	770,570
August	299,613	487,258	786,866	299,613	487,253	786,866
September	223,836	529,452	753,288	224,016	529,452	753,468
October	253,598	573,293	826,891	261,206	573,293	834,499
November	215,862	562,998	778,860	227,634	562,998	790,632
December	387,058	618,968	1,006,026	406,517	618,968	1,025,485
1908.						
January	368,090	782,244	1,150,884	424,930	802,092	1,227,022
February	422,782	753,970	1,176,752	478,664	769,601	1,248,265
March	467,113	749,151	1,216,264	522,858	768,027	1,290,885
April	426,056	764,100	1,190,156	471,574	771,000	1,242,574
May	300,333	629,846	930,179	325,584	635,256	960,840
June	262,278	836,790	1,099,068	288,319	845,715	1,134,032
Total	3,859,139	7,826,115	11,685,254	4,163,435	7,901,703	12,065,138

It will be seen from the above table that the maximum monthly amount of material excavated in this division during the fiscal year was 1,290,885 cubic yards, removed in March. This amount is more than two and one-half times the maximum monthly excavation as given in available records, made by the French in the Culebra division, their highest monthly total in this division being 502,250 cubic yards in February, 1886.

With the exception of 59,778 cubic yards of material, removed by hand from the quarry in the canal prism at Bas Obispo, all material is handled by steam shovels and dirt trains, and is carried to dumps situated at distances varying from 1 mile to 24 miles, the average haul at present being about 10 miles.

BLASTING.

The total amount of material actually mined during the fiscal year was 8,106,716 cubic yards.

During the year 66 well or mechanical churn drills were in operation and 241 air drills. All drills are run by compressed air.

The number of linear feet of holes drilled during the fiscal year were as follows:

	Linear feet.	Miles.
Steam and air drilling	1,224,902	231.99
Well or mechanical churn drilling	613,568	116.20
Hand drilling	210,461	39.86
Total	2,048,931	388.05

The quantity of explosives used during the year amounted to a total of 2,352 tons, costing $597,275.53.

STEAM SHOVELS.

The total number of steam shovels assigned to the Culebra division during the fiscal year was 59.

These shovels were of five sizes, 45-ton Bucyrus, 70-ton Bucyrus, 95-ton Bucyrus, Model No. 60 Marion, and Model No. 91 Marion, with dipper capacity of 1¾, 2½, 5, 2½, and 5 cubic yards, respectively.

The number of cubic yards excavated per hour, while under steam, by shovels averaged 123 for the present fiscal year, as compared with 88 for the previous fiscal year, an increase of about 40 per cent.

The largest daily output during the year was made by steam shovel No. 226, a 95-ton shovel, which in eight hours took out 3,570 cubic yards of earth.

The largest monthly output was made by steam shovel No. 219, a 95-ton shovel, which in twenty-four working days took out 53,048 cubic yards of rock.

The largest annual output was made by steam shovel No. 222, a 95-ton shovel, which excavated during the fiscal year 387,163 cubic yards of rock and 14,846 cubic yards of earth, a total of 402,009 cubic yards, in 295 working days.

A table showing the performances of steam shovels in the Culebra division for the fiscal year ending June 30, 1908, follows:

Month.	Number of working days.	Output per shovel.				Rainfall at—	
		Per day.	Per month.	Per hour under steam.	Per hour at work.	Empire.	Culebra.
1907.		*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Inches.*	*Inches.*
July	26	680	17,670	89	167	9.85	9.42
August	27	729	19,680	95	166	11.28	11.81
September	24	811	19,468	106	182	10.86	11.38
October	27	813	21,963	103	177	15.44	15.27
November	24	784	18,818	107	184	10.40	6.91
December	25	965	24,113	126	199	1.47	2.30
1908.							
January	26	1,084	28,177	189	219	.75	.91
February	24	1,186	28,475	152	230	.00	.01
March	26	1,171	30,451	150	228	.41	.18
April	25	1,202	30,031	155	232	1.36	1.67
May	25	918	22,947	119	198	12.91	12.68
June	26	1,011	26,281	132	205	8.21	8.86

It must be remembered that this performance is based upon a working day of but eight hours, whereas contractors in the United States usually work their steam shovels about ten hours per day.

TRANSPORTATION.

The equipment in operation under the transportation department of the Culebra division on June 30, 1908, was in good condition and consisted of the following:

Locomotives	156
Lidgerwood plows	10
Lidgerwood unloaders	26
Spreaders	23
Lidgerwood flat cars	1,267
12-yard western dump cars	258
20-yard western dump cars	110
Ballast cars	29
12-yard Oliver dump cars	132
Steel flat cars, 40-ton	300
Steel flat cars, 50-ton	183
Track-throwing machines	5

TRACKS.

New track to the amount of 44.79 miles was laid during the fiscal year, making a total for the division on June 30, 1908, of 151.57 miles, all laid with 70-pound American rail and passable for the heaviest trains.

Along the bottom of the canal from Culebra Summit to Las Cascadas there are 4 running tracks, and from Culebra Summit to Pedro Miguel there are 3 running tracks. These tracks are now in a very satisfactory condition.

A plat showing the tracks and dumps used for handling material from the Culebra division accompanies this report. (Plate 26.)

DUMPS.

During the year all inside dumps have been completed, thus necessitating the hauling of practically all the material over the main line of the Panama Railroad to Gorgona and Tabernilla dumps on the north and the new dumps at Miraflores and La Boca on the south. The dumps at La Boca and Miraflores have been developed during the past fiscal year and have a daily capacity of about 12,000 cubic yards each. Development of the Tabernilla dump ground has been completed during the past year, and 16,000 cubic yards of material per day can now be disposed of there.

On March 20, 1908, by direction of the chairman and chief engineer, Isthmian Canal Commission, the Culebra division commenced to furnish stone from the "cut" at Bas Obispo for use at the Gatun dam. (Plate 6.) About 1,300 cubic yards of stone daily are now carried from Bas Obispo to Gatun, a distance of about 24 miles.

YARDS.

Up to the present fiscal year material taken from the "cut" was carried to two principal yards, one at Las Cascadas and the other at Pedro Miguel, and made up into trains for transportation over the main line of the Panama Railroad to the dumps. Considerable unavoidable delay and some additional expense attached to this method of handling the material, and it was deemed expedient to adopt the

general rule of running such trains direct from the shovels to the larger dumping grounds. This plan has been adopted with complete success and has resulted in an increase of capacity in the transportation equipment, as quicker trips can be made by the present method than by that formerly adopted, and a greater amount of material can be handled by an equal number of cars.

LABOR SITUATION.

The labor situation during the fiscal year has been very satisfactory, and there has been no difficulty in obtaining all men needed in the various departments of the work. In fact the supply has usually been greater than the requirements of the work. On the Culebra division Spaniards, Italians, and West Indian negroes comprise most of the day laborers.

The daily average number of laborers employed in the Culebra division during the fiscal year was 6,501.

COST.

Considering the total output in the Culebra division for the fiscal year, the average cost of the various items of expense is given in the following:

Cost per cubic yard in cents.

Mining	14.47
Loading	11.65
Transportation	19.36
Dumping	14.11
Tracks	11.52
Division office and supervision	1.45
Total (not including plant and general items)	72.56

COAL CONSUMED.

The amount of coal consumed on the Culebra division during the fiscal year was 128,728.3 tons, valued at $817,424.77, or $6.35 per ton. The high cost of soft coal as given above adds very materially in the cost of work as compared with that of similar work in localities in the United States where coal is very much cheaper.

DIVERSION CHANNELS.

It was considered very important to divert from the canal, both for construction purposes as well as for economy and maintenance after the canal has been completed, all waters which would flow into it from the adjacent watershed. Therefore, as outlined in the previous annual report, work was commenced during the fiscal year and executed as rapidly as possible, with the view of repairing and putting in operation the old French diversion channel extending on the west side of the canal from Culebra and emptying into the Chagres near Matachin. This channel is known as the "Camacho diversion."

In order to make this diversion channel available it was necessary to construct a new channel, revetted with stone, through the Whitehouse yard; to build a dam across the Obispo River at Bas Obispo; to clear out the old French tunnel through the hill at the latter place,

and to clean out the artificial channel below it. These operations involved the handling of 85,657 cubic yards of material.

The entire work was accomplished successfully before the end of the fiscal year, and, as a consequence, an efficient diversion channel now exists on the west side of the canal from the Continental Divide, south of Culebra, to the Chagres River, near Matachin.

For taking care of the waters of the Obispo River and other streams on the east side of the canal between Gold Hill and Gamboa, a diversion channel, known as the Obispo diversion, has been located, and work upon it has been pushed with all possible speed.

At the close of the fiscal year this channel had been completed from Gold Hill to a point opposite Las Cascadas and work was in progress between Las Cascadas and Gamboa. In the construction of this diversion channel 313,511 cubic yards of material were excavated during the fiscal year, and there remain about 400,000 cubic yards yet to be excavated in order to complete the channel.

SLIDES.

On October 4 the Cucaracha slide, which had caused more or less inconvenience since work was commenced in that vicinity by the French in 1884, began to move toward the east edge of the canal. The motion at first was quite rapid, being at the rate of 14 feet in twenty-four hours, but by the close of the month its rate of motion had decreased to 4 feet in twenty-four hours. About 113,000 cubic yards of material had then moved into an area which had previously been excavated, and for a time all passage of material by trains through the bottom of the canal was shut off. Electric arc lights were installed so that operations might be carried on at night and a 4-inch stream of water at high pressure was brought to the aid of the steam shovels which were working on the portion of the slide within the canal prism. Work was prosecuted without intermission, day and night, under extremely disadvantageous circumstances due to the heavy rainfall for the month. By the end of October more material was being removed from the "cut" than was coming in from the slide and sufficient space was gained to enable two tracks to be put through that part of the canal previously covered by the slide.

The total area of the slide was 34,445 square yards and the estimated amount of material in motion was 600,000 cubic yards.

The total amount of material removed from it since the slide commenced to give trouble is 445,000 cubic yards. The most distant point of the slide from the edge of the canal was 910 feet. A photograph of this slide is attached herewith. (Plate 11.)

The removal of the material from this slide was prosecuted without any special difficulty as soon as the dry season commenced, and a wide berm was opened through the slide on the east side of the canal in order that, should trouble arise in future, steam shovels could be placed on this berm and the sliding material removed at this point instead of permitting it to get into the canal.

This slide, which is the largest yet encountered, has given no trouble so far during the present rainy season, and it is believed that its worst phase has passed.

Another slide at Paraiso, which originally developed when the French were working upon the canal, commenced to give trouble in

April of this year. This slide is located on the east bank of the canal, and extends up a narrow valley to an extreme distance of 750 feet from the edge of the canal. The area of this slide is approximately 16,700 square yards, and the amount of material in motion is 140,000 cubic yards. Its rate of motion is comparatively slow, and it has caused much less annoyance than the Cucaracha slide.

About 90,000 cubic yards from this slide have been removed by steam shovels and carried to the dumps. It is believed that the material in this slide will be handled without any particular difficulty. A photograph of this slide is attached herewith. (Plate 12.)

During the present season two slides of comparatively novel character, inasmuch as they developed during the last dry season, originated on the upper level of the Culebra Cut.

The most southerly of the two is located on the west bank of the canal at the village of New Culebra, which is built entirely upon an old French dump. This material, which had caused a little trouble previously, began to break away in March and slide into the cut. The most distant point of the slide from the edge of the cut was about 420 feet. The area of the slide was about 6,110 square yards, and the total amount of material in motion was about 50,000 cubic yards, about 40,000 cubic yards of which have been removed from the cut and carried to the dumps. (Plate 13.)

The other slide is located directly opposite the village of Las Cascadas, and extends back from the edge of the canal for an extreme distance of 230 feet. The area of this slide is approximately 5,433 square yards and the amount of material in motion about 100,000 cubic yards. The amount of material removed from this slide by steam shovels and carried to the dumps is about 53,000 cubic yards. (Plate 14.)

The two slides last described are the only ones which have occurred during the dry season, and the bulk of the material composing them appeared fairly dry, especially in the case of the slide opposite Las Cascadas. The material at the bottom of the slide at the village of New Culebra was moist, but not at all wet, and in both cases the mass in motion was a superficial top covering of earth 20 to 30 feet thick, deficient in cohesion and comparatively dry, moving upon a gently sloping bed of much harder material, which was smooth and soapy to the touch.

The four slides just mentioned are the only ones which have caused trouble since the United States assumed control of the canal. They have proved annoying and have at times reduced the output and increased the cost of excavation in the Culebra division, but have never presented any real obstacle to the successful prosecution of the work of excavation, but as they have been much discussed at times by persons who have not had the opportunity to see them on the spot, it has been thought proper to describe them somewhat in detail and to give photographs of each of the slides.

REMARKS.

In comparing the cost of work upon the Isthmus with that of similar work in the United States certain conditions existing in the former locality must be taken into consideration. The wages paid for skilled labor on the Isthmus are, on an average, from 40 to 70 per cent higher

than is paid for the same class of labor in the United States. The working day here is but eight hours in length, while on private enterprises in the United States the working day is usually ten hours.

In the greater portion of the eastern and southeastern parts of the United States the price of soft coal does not exceed from $3 to $3.50 per ton. The coal used on the Culebra division during the fiscal year ending June 30, 1908, cost $6.35 per ton.

Owing to the long distance from the source of supply, machinery and material of all classes are more expensive than in the United States.

In addition to these disadvantages, the climate is not one conducive to great physical and mental activity, and the rainfall is so heavy, averaging about 95 inches per annum in the Culebra division, that it interferes considerably with the rapid prosecution of the work. This can readily be appreciated when it is remembered that the greater part of this rainfall occurs during the eight months comprising the rainy season.

CHANGES IN ORGANIZATION.

The resignation of Mr. D. W. Bolich, division engineer, was accepted May 7, 1908, to take effect at the expiration of forty-two days' leave granted him, beginning May 11.

The resignation of Mr. M. K. Jones, superintendent of transportation, was accepted July 2, to take effect at the expiration of forty-two days' leave, which was granted him beginning July 11.

The resignation of Mr. Sydney J. Kennedy, chief clerk, was accepted May 20, to take effect at the expiration of forty-two days' leave, which was granted him beginning May 20, 1908.

The resignation of Mr. Fred L. Hartigan, superintendent of construction, was accepted June 13, to take effect at the expiration of forty-two days' leave, which was granted him beginning April 20.

Mr. D. B. Brown, superintendent of construction, was discharged June 30, 1908, on account of reduction of force.

Mr. L. K. Rourke, assistant division engineer, was appointed division engineer, effective June 22, 1908, vice D. W. Bolich, resigned.

Mr. A. E. Bronk was appointed chief clerk, effective May 20, 1908, vice Mr. Sydney J. Kennedy, resigned.

CHAGRES DIVISION.

The Chagres division extends from Gatun to the point where the canal crosses the Chagres River at Gamboa, a total distance of about 23 miles. The river crosses the center line of the canal twenty-three times within the limits of this division, and, as a consequence, a considerable part of the area adjacent to the center line of the canal is subject to overflow at times of high floods in the Chagres River, and work in this division is liable to interruptions from this cause during the rainy season.

At the close of the previous fiscal year no construction work had been accomplished, but surveys were in progress for measuring accurately and permanently marking the center line of the canal and obtaining cross sections at intervals of 100 feet. The surveys which had been begun in 1907 were continued, and the last cross sections

were finished on May 1, 1908. About 1,100,000 linear feet of cross section levels were run between Peña Blanca (mile 16) and Gamboa (mile 30¾).

AMOUNT OF MATERIAL REMOVED.

A revised estimate of the amount of material to be removed gave 12,256,300 cubic yards, of which about 8,313,500 cubic yards were earth and 3,942,800 cubic yards were rock. Changes of alignment were approved during the fiscal year which eliminated 1,264,700 cubic yards of earth and 264,300 cubic yards of rock. There were excavated during the fiscal year 1,774,124 cubic yards of earth and rock, leaving 8,953,176 cubic yards of material to be removed at the close of the fiscal year, of which amount 5,857,879 cubic yards were earth and 3,095,297 cubic yards were rock. Between Peña Blanca and Gatun there is no excavation with the exception of approximately 350 cubic yards at a point near the latter place.

During the year about 4,700 feet of borings were taken in the canal prism, between Gamboa and Bohio, to aid in determining the nature of the material, particularly with reference to the best method of removal. This work will probably be completed in July, 1908.

EXCAVATION.

Excavation by steam shovels was carried on during the fiscal year at four points on the division in the following order:

Work was begun at San Pablo on August 7, 1907. The estimated amount of material to be excavated in this locality was 1,379,639 cubic yards, of which 634,832 cubic yards (46 per cent) had been removed up to July 1, 1908. The amount of construction track at San Pablo at the end of the fiscal year was 7.6 miles.

Work was begun at Caimito on October 1, 1907. The estimated amount of material to be removed was 2,079,493 cubic yards, of which 553,374 cubic yards (27 per cent) had been removed up to July 1, 1908. The amount of construction track at Caimito on July 1, 1908, was 8.03 miles.

Work was commenced at Matachin on December 30, 1907, with an estimated amount of 1,552,000 cubic yards of material to be removed. Of this amount, 434,151 cubic yards (28 per cent) had been removed up to July 1, 1908. The amount of construction track at Matachin at the close of the fiscal year was 7.15 miles.

Work was started at Santa Cruz on February 24, 1908. The estimated amount of material to be removed at this point was 1,277,800 cubic yards, of which 138,896 cubic yards (11 per cent) had been removed at the end of the fiscal year. The amount of construction track at Santa Cruz on July 1, 1908, was 3.63 miles.

The amount of material removed monthly is shown in the following table:

Months.	From canal prism.			Grand total.
	Earth.	Rock.	Not classified.	
1907.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
August			2,900	2,900
September			21,546	21,546
October			25,627	25,627
November	36,748	7,296		44,044
December	85,173	13,479		98,652
1908.				
January	121,793	47,654		169,447
February	151,150	48,995		200,145
March	255,602	68,631		324,233
April	243,001	86,482		329,483
May	124,136	111,766		235,902
June	148,245	173,900		322,145
Total	1,165,848	558,203	50,073	1,774,124

At Santa Cruz and Matachin levees have been built at each end of the cut as a protection against floods in the Chagres River, and pumps installed to drain the excavation area thus protected.

The total amount of construction track in use on the Chagres division on July 1, 1908, was 26.41 miles.

BLASTING.

There were used in blasting operations in the Chagres division during the fiscal year 779,687 pounds of dynamite. An electric line for carrying current from Gorgona shops to Matachin has been in operation for about three months and gives more satisfactory results than were obtained by the use of the firing batteries. An extension of this line to Santa Cruz is almost completed.

The number of linear feet of holes drilled during the fiscal year was as follows:

	Linear feet.	Miles.
Steam and air drills	17,178	3.25
Well or churn drills	125,976	23.86
Hand drills	58,826	11.14
Total	201,980	38.25

PERFORMANCE OF STEAM SHOVELS.

The average amount excavated per shovel day (of eight hours) gradually increased to 1,121 cubic yards in April, during which month the average number of steam shovels in use on the entire division was as follows:

45-ton shovels	2.92
60-ton shovels	2.00
70-ton shovels	5.64
90-ton shovels	1.20

This average dropped somewhat in May, but increased in June to 1,013 cubic yards, with an average of 12.23 shovels in use during the

latter month. Further details in reference to the performance of steam shovels in the Chagres division are given in the following table:

Period.	Rainfall.	Average number of shovels at work.	Number of working days in month.	Average output per shovel per day (8 hours).	Average output per shovel per month.
1907.	*Inches.*			*Cubic yards.*	*Cubic yards.*
August	12.20	0.15	27	716	19,333
September	14.71	.92	24	976	23,420
October	13.62	2.22	27	428	11,544
November	9.85	3.00	24	612	14,681
December	2.26	6.12	25	630	15,756
1908.					
January	.20	8.11	26	797	20,720
February	.11	10.33	24	798	19,144
March	.41	11.47	26	1,082	28,094
April	1.81	11.76	25	1,121	28,018
May	13.18	11.68	25	808	20,197
June	6.55	12.23	26	1,013	26,341

EQUIPMENT.

The principal articles of equipment in use on the Chagres division at the close of the fiscal year are shown in the following table:

Locomotives	50
Steam shovels	15
Spreaders	4
Track shifters	2
Pile drivers	2
Cranes	1
Dump cars, old French	410
Dump cars, Oliver	235

Of the 50 locomotives in use at the end of the year, 47 were engines which had been in use by the French and which had been repaired and put in commission. Old French dump cars were used exclusively until the arrival of the new Oliver dump cars in the spring.

NUMBER OF EMPLOYEES.

On June 30, 1908, there were 236 employees on the gold roll and 1,765 on the silver roll in the Chagres division, a total of 2,001.

COST OF EXCAVATION.

The cost of excavation in the Chagres division is shown in the following table. This cost includes considerable preliminary work, track work, etc., part of the benefit of which will appear in the cost for the removal of material yet remaining. It also includes the cost of blasting 620,980 cubic yards of material which had been blasted ahead of the steam shovels; it does not include the cost of plant nor certain general items not directly connected with the work of excavation:

	Cost per cubic yard in cents.
Mining	11.82
Loading	10.52
Transportation	12.97
Dumping	8.90
Tracks	14.45
Division office and supervision	2.81
Total	61.47

PERSONNEL.

The personnel of the Chagres division at the close of the fiscal year was as follows: Maj. Edgar Jadwin, Corps of Engineers, U. S. Army, division engineer, appointed July 25, 1907; Capt. George M. Hoffman, Corps of Engineers, U. S. Army, assistant division engineer, appointed January 4, 1908; Mr. R. W. Hebard, resident engineer, appointed August 2, 1907; Mr. W. G. Shea, superintendent of construction, appointed November 1, 1907; Mr. F. C. Stanton, assistant engineer, appointed September 25, 1907; Mr. Samuel G. Baker, acting chief clerk, appointed August 8, 1907; Mr. F. J. Fussner, acting chief timekeeper, appointed December 5, 1907; Mr. James H. Adams, assistant superintendent of construction, appointed general foreman in charge August 5, 1907, appointed assistant superintendent, November 4, 1907; Mr. Ben Johnson, assistant superintendent of construction, appointed December 14, 1907; Mr. Peter Donnelly, assistant superintendent of construction, appointed April 1, 1908.

Colon Dredging Division.

SURVEYS AND OFFICE WORK.

The party working on the canal center line, the survey of which was begun in January, 1907, completed the cross-section work to station 44 of the nineteenth mile, and referencing of monuments to Bohio, P. I., eighteenth mile. Eighty-three thousand seven hundred feet of cross section (level) was completed, 78,400 feet of cross section staked out, 4,600 feet of check levels, and 8,300 feet of transit line referencing monuments were run before this work was turned over to Maj. Edgar Jadwin, division engineer, on the organization of the Chagres division.

In the office plans were made for the reconstruction of old dredges and for the construction of a dipper dredge; a suction dredge cutter was designed, details for towboat worked out, tracings made of dredge parts, blueprints made as required, and drawings and records cared for.

EXCAVATION BY STEAM SHOVELS AT MINDI.

In July a cut was started through the Mindi Hills on the axis of the canal, by shovel No. 108. In August shovel No. 112 was added. Two shovels have been at work during the year, No. 133 replacing No. 112 in February. Five hundred and thirty-six thousand nine hundred and fifty-nine cubic yards have been excavated at a cost of 42.44 cents per cubic yard. This cutting includes both swamp and rock work. (Plate 23.)

Clearing between Mindi and Limon Bay was completed in August.

Five thousand four hundred and fifty-five feet of tripod drilling, 27,888 feet of well drilling, and 71,568 feet of hand drilling were done during the year.

DREDGING.

The old French ladder dredge, *No. 6*, has been at work throughout the year in the canal prism in Limon Bay, and has excavated 1,322,525 cubic yards.

The 16-inch suction dredge was at the mouth of the Mindi River at the beginning of the year and removed 1,000 yards there before she was taken to the dock for repairs. On July 20 she was placed in the canal prism near Mindi and excavated 30,968 cubic yards. On October 10 she was moved to the Union Oil Company's plant near Cristobal dry dock and did some work for the sanitary department, excavating 5,488 cubic yards. On October 17, after being repaired, she was moved to Porto Bello, where she removed 10,306 cubic yards up to January 27, 1908, when she was returned to the dry dock and laid up. In June she did a little filling for a corral at Folks River, excavating 2,700 cubic yards.

The dipper dredge *Chagres* was in Limon Bay at the beginning of the year, the sea being so rough as to hinder effective work. She worked at Mindi for a few days to open the old French canal to the sea, then removed a point in this canal north of Mindi River to allow the passage of loaded scows. During the month 4,600 cubic yards were removed. In August 5,127 yards were removed from the Mindi River, and on August 16 the dredge was moved to the canal prism, where she excavated 15,000 yards, moving on September 6 to the Chagres River at Gatun, where 38,425 yards were excavated. On November 7 the dredge went to work in the prism, removing 32,595 cubic yards before she was docked for repairs late in December. In February she was set to work digging out the cofferdam at the dry dock, and on the 15th went to the old French canal above that point, excavating 16,625 cubic yards, 7,812 of which were rock. During March the dredge was laid up, except while dredging 350 yards at coal dock 14. On March 31 she went again to the old French canal above the dry dock for a week, and on April 6 to pier 11, dredging 13,677 yards before being laid up in May for repairs. On June 3 she resumed operations at pier No. 1 and excavated 7,250 yards before she was laid up for repairs late in the month.

The new seagoing suction dredge *Ancon* began work on August 12 with a single crew, and on the 28th a double crew was put on. She dredges a course in Limon Bay over the line of the canal to a dumping point 1½ miles northeast of Toro Point Light-House and has excavated 3,040,959 cubic yards during the year.

The dipper dredge *Mindi* started work in the old French canal late in November, excavating 4,500 yards. She was laid up for repairs during December; resumed work in January, losing about twelve days in that month for repairs, and excavated 87,171 cubic yards, shutting down at the end of March for repairs. She went in the canal prism on April 4 and worked for about two weeks, removing 14,785 yards, being again laid up for lack of a tug to serve her. On June 11 she went back to the canal prism at Mindi with a single crew and excavated 6,550 yards during the month.

The old French ladder dredge *No. 1* began work on February 12 in the canal prism in Limon Bay, where she was still dredging at the end of the year, having excavated 498,730 cubic yards.

The total monthly excavation by dredges in this division is shown in the following table:

Month.	From canal prism, soft material.	From accessory works.			Grand total.
		Soft material.	Rock.	Total.	
1907.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	104,322	5,600	....	5,600	109,922
August	189,170	5,127	....	5,127	194,297
September	408,842	....	....	....	408,842
October	409,632	5,488	....	5,488	415,120
November	417 297	5,500	....	5,500	422,797
December	428,053	14,782	....	14,782	442,835
1908.					
January	444,403	46,298	....	46,298	490,701
February	401,887	13,418	12,417	25,835	427,722
March	515,223	31,663	....	31,663	546,886
April	496,366	....	....	....	496,366
May	564,386	....	....	....	564,386
June	572,749	....	....	....	572,749
Fiscal year	4,947,330	127,876	12,417	140,293	5,087,623

The total expenditures in connection with dredging amounted during the fiscal year to $530,739.99, making the average cost per cubic yard, place measurement, for all material dredged during this period 10.43 cents. This does not include " plant " or general items.

MACHINE SHOP AND DRY DOCK.

A Lidgerwood engine and boiler have been added, the old French lathe has been replaced with a new 36-inch machine, a new forge has been installed in the blacksmith shop, an old French pump overhauled and fitted up, the boring mill and planing machine reset, new blower put in blacksmith shop, old French shaper removed and overhauled and new lathe put in, air-compresser engine installed in pump house, engines installed in new boiler and blacksmith shop section, foundations for machinery put in, and new shop roof constructed. Shop and outside tools and equipment have been kept in repair, parts made for outfits on the work at Gatun and at Porto Bello, and repairs as follows made to individual plant:

Tug *Gatun:* Extensive repairs and overhauling.

Launch *Ruth:* Machinery overhauled and repaired.

Launch *Grace:* Machinery overhauled and repaired.

Launch *Balboa:* General overhauling and fitting up.

Old French ladder dredge *No. 1:* Extensive repairs and overhauling, and installation of electric lights.

Old French ladder dredge *No. 6:* Numerous repairs to machinery and construction of galley and mess room.

Clapets Nos. 2, 3, 4, 12, and 14: Numerous repairs and general overhauling.

Suction dredge, 16-inch: Repairs to machinery and pumping plant.

Dipper dredges *Chagres* and *Mindi:* Numerous repairs and some modifications.

Seagoing suction dredge *Ancon:* New suction pipes were made and a number of repairs and modifications effected.

Tugs *Porto Bello, Cristobal,* and *Mariner:* General repairs and overhauling.

In addition repairs were made to the dumping scows, clam-shell dredge, water barges, Panama Railroad barges, coaling derrick, floating pile driver, M. & S. launch, M. & S. crane No. 23, Gantry crane, dry-dock crane, B. C. crane No. 34, and locomotive No. 472.

Twenty-inch pipe-line suction dredges: Three dredges, received knocked-down from the Maryland Steel Company for the Gatun dam division, have been erected and pontoons and pipe lines built complete for same. Two are completed and the third well under way, 25 per cent of the machinery, 75 per cent of the house, 40 per cent of the wiring, and 50 per cent of the piping being completed.

DRY DOCK.

The work of extension, begun during last year, was completed. A hoist derrick was constructed, new pumps and other machinery installed, and working repairs made to the plant. Work has continued on the clearing and leveling of grounds.

NEW PLANT.

A 5-yard dipper dredge which had been contracted for with the Featherstone Foundry and Machine Company was delivered, and has been named *Mindi.*

RAINFALL.

The rainfall for the year amounted to 137.73 inches.

LA BOCA DREDGING DIVISION.

The change in location of the locks and dams at the Pacific end of the canal entails the dredging of a channel approximately 3 miles long, in addition to the dredging contemplated at the time that the last annual report was submitted. The lowest estimate of the amount of rock to be removed from this additional channel is 1,500,000 cubic yards, but the data from which such estimates have been prepared are still rather incomplete. To obtain accurate information on this subject three lines of borings are being made along the center and side lines of the channel every 100 feet.

It is possible that a portion of this rock can be removed without mining, as some of the samples obtained are very soft. However, enough hard rock will be encountered to necessitate the purchase of considerable submarine rock mining machinery, together with dredges and barges for handling the output. One rock-drill barge and one Lobnitz rock breaker have been ordered, and after comparative tests requisition will be placed for as many of these machines as the drill explorations show will be required to complete the work within the proper time limit.

DREDGING.

After the abandonment of the lock site at La Boca, it was necessary to change slightly the line of the new channel to deep water in order to connect it with the portion of the old French channel that will be used under the approved final plan. The line was so located that all of the dredging, with the exception of a small cut made by the dipper dredge, that had previously been done, would be within the limits to be dredged for the present approved channel.

Twenty-five nun buoys have been received from the United States for marking the limits of the new channel and 3,000-pound reenforced concrete anchors have been made to hold the buoys in place.

The seagoing suction dredge *Culebra* has been working along the outer entrance of the channel since going into commission on January 21. The regular cut of this boat has been 12,000 feet long. On January 23 the cables of the Central and South American Telegraph Company, the location of which was unknown to the employees of the Isthmian Canal Commission, were picked up on the suction head of this boat and considerably damaged. Until the line was relaid to the seaward of the islands (Naos, Perico, Flamenco, and Culebra) the run of the dredge had to be shortened to avoid further damage to the cables. On April 20 the starboard high-pressure main pump cylinder of the vessel broke, and was at once removed and sent to the Gorgona shops for repair and a new cylinder ordered from the United States. Considerable delay was experienced in getting this cylinder, and it was not until June 10 that both pumps were again in commission. In the meantime the *Culebra* had been working with but one pump, making about 75 to 80 per cent of the regular output. Monthly soundings have demonstrated the fact that the suction heads have been running in parallel grooves along the bottom of the cut, which become more marked as the work progresses. To overcome this difficulty a heavy drag of railroad iron has been made, and this is hauled over the cut of the *Culebra* by a tug.

One old French ladder dredge has been kept in constant operation during the year and another one since September 24, making a channel through the mud flat from the north end of the cut of the *Culebra* to the intersection of the new and French channels, about 2,000 feet south of the Old Panama Railroad wharf.

Dredge A No. 2 (an old French ladder dredge) worked through the outer portion of this flat until May 3, when it was taken to the ships ways for overhauling, and the *Gopher*, A No. 3 (an old French ladder dredge), was placed in the same cut. An outcropping of soft rock was encountered by this dredge on June 15 at a depth of —33 feet, but from indications this ledge is not of great extent. Dredge No. 14 (an old French ladder dredge) has been working from the center of the flat toward the intersection of the two channels, which point was reached during the latter part of June. The entrance of the new channel was widened and deepened enough to allow the passage of clapets on June 25. When the cut that these two dredges are now upon is finished the *Culebra* will have a straight cut from the end of the Panama Railroad pier to deep water, permitting the ladder dredges to be used farther up the canal. (Plate 24.)

The dipper dredge was taken out of commission on January 17, 1908, and taken to the ships ways for overhauling, it being the intention to use this machine for subaqueous rock removal. It has been found that a dredge of this type is not as economical for excavation in soft material in Panama Bay as the ladder dredges, and it will not be placed in commission until rock removal is begun.

The following table shows the output by months during the fiscal year and the comparative cost of excavation by the three different types of dredges:

Month of—	Suction.		Ladder.		Dipper.	
	Output.	Cost.	Output.	Cost.	Output.	Cost.
1907.	*Cubic yds.*		*Cubic yds.*		*Cubic yds.*	
July	....	....	76,698	$0.221	31,640	$0.2805
August	....	....	118,124	.144	56,160	.2568
September	....	....	131,908	.127	22,067	.6913
October	....	....	287,107	.124	70,015	.2281
November	....	....	294,073	.086	71,350	.1851
December	....	....	303,142	.081	46,409	.2464
1908.						
January	111,526	$0.0269	314,591	.078	34,183	.2243
February	438,036	.0318	225,488	.104	....	....
March	522,577	.0276	260,704	.098	....	....
April	427,435	.0278	249,104	.095	....	....
May	303,755	.0420	226,711	.1148	....	....
June	371,625	.0330	284,996	.0934	....	....
Total for year	2,174,954	....	2,772,641	....	825,774	....
Average cost	....	.0814	....	.1066	....	.2610

The total monthly output by all dredges is given in the following table:

Month.	From canal prism, soft material.	From accessory works, soft material.	Grand total canal prism and accessory works.
1907.	*Cu. yds.*	*Cu. yds.*	
July	108,338	....	108,338
August	168,284	....	168,284
September	144,625	9,350	153,975
October	357,122	....	357,122
November	365,423	....	365,423
December	349,551	....	349,551
1908.			
January	460,250	....	460,250
February	663,519	....	663,519
March	783,281	....	783,281
April	676,559	....	676,559
May	530,466	....	530,466
June	656,621	....	656,621
Total	5,264,019	9,350	5,273,369

The average cost per cubic yard, place measurement, for all material dredged during the fiscal year was 8.37 cents, exclusive of cost of " plant " and general items.

DRY EXCAVATION.

During January one of the construction tracks of the Pacific lock division was extended to Cardenas Hill, and early in February a steam shovel (No. 157) was put in commission. Owing to the fact that the ground is very soft and partially flooded at high tide, it was necessary to use the lightest French rolling stock obtainable. The spoil from this steam shovel is being dumped along the east bank of the Rio Grande, parallel to the canal line, and this dump will be used as a retaining wall over which suction dredges can pump their dis-

charge. At some points the ground is so swampy that it has been necessary to lay a brush mattress before any fill could be made or track laid. Owing to small output, 55,490 cubic yards during the fiscal year, and heavy cost of dump, the cost of excavation, 55.08 cents per cubic yard, is somewhat large for earth removal; but as compared with the cost of trestle work along the dike line, the retaining levee, as now built, is very economical. It is the intention to cross the river with a trestle (forming a dam by making fill from same) and extend the levee along the other side of the river (and canal axis) toward La Boca. To date 3,000 feet of dyke have been finished and a partially completed line has been completed 1,600 feet farther. Surveys have been made to determine the most practicable line for the diversion channel to take care of the drainage above the dam referred to.

The steam shovel has gone considerably below high-water level, and it was found necessary to erect a small cofferdam and install a pump to permit the shovel to work at all stages of water.

PLANT.

The old French ladder dredge, No. 14, was under process of rebuilding at the beginning of this year. This work was completed during September, 1907, and the plant put in commission in the new channel on September 24.

The old French ladder dredge, A–No. 2, has been in commission for about five years, with but comparatively light repairs, and upon the completion of the rebuilding of A–No. 3 (*Gopher*) A–No. 2 was taken out of commission (May 3, 1908) and taken to the shipsways for complete overhauling.

Authority was issued on August 30, 1907, to rebuild the old French ladder dredge A–No. 3 (*Gopher*) and the work was at once begun. The boat was launched from the ways on March 3 and put into commission on May 4 in the cut previously occupied by dredge A–No. 2.

The work of erection of dipper dredge No. 1, by the Atlantic, Gulf and Pacific Company, was completed on July 10, and the plant put into commission on the 11th. The results obtained from this dredge while working in soft material were not satisfactory owing to the great depth of the water and to the unusually large tidal range. The output was small, and the breakages frequent and expensive. The boat was finally taken out of commission on January 17 and taken to the shipsways for overhauling. It has not since been in commission, but will be used during the next fiscal year for subaqueous rock excavation.

Material for the 20-inch pipe-line suction dredge No. 84 was received during the early part of the year, and ways were prepared for its erection. The hull work was completed early in May, and the boat was launched on May 14. The internal machinery is now being installed. Complete equipment of pontons and pipe line has been made for this plant.

The seagoing suction dredge, *Culebra*, after a voyage of 12,000 miles, arrived in the Bay of Panama on December 28, and after slight overhauling was put in commission on January 21. The performance of this dredge has been excellent and it is a valuable addition to the plant. (Plate 25.)

The tug *La Boca* (formerly the *E. G. Reynolds*) arrived at La Boca, via the Straits of Magellan, on February 23 after a very rough passage. The vessel was given a general overhauling and fitted for service as dredge tender and tug. This boat is a powerful tug, of excellent design, and has given complete satisfaction.

Instructions were received to rebuild water boat *No. 2* for the use of the sanitary department. The boat was put on the ways during March, 1908, and the old plating replaced. The hull was launched on June 8, and the internal machinery is being installed; superstructure erected, deck laid, etc.

The necessary material was collected from French stock lying in the vicinity of La Boca for an 100-ton coal barge. The sections were taken to the shipsways, assembled, and the barge launched on November 6, 1907.

A boiler, engines, and hoisting machinery were installed in a small French hull found in the Rio Grande; a derrick and boom erected, and a clam-shell bucket provided, making a fairly satisfactory coal hoist, which is used in connection with the dredging plant.

Prior to the change in lock and dam plans in the Pacific division it was intended to abandon the machine shop and shipsways within a few years, and for this reason no repairs were made that were not absolutely necessary at the time. Since it has been settled that Old La Boca will not be flooded, the shops are being put in condition for permanent use. A new roof has been placed on the shipsways, extensions made to both the shop and shipsways, and a number of new machines installed.

Plans have been prepared for an 800-foot wharf, to be located near the shipsways, and fronting on the Rio Grande. Extensive borings and test pit work have been done to determine the nature of the foundation and requisition will soon be made for all material required, and the work of erection pushed.

All clapets, launches, dredges, etc., have been kept in running repair during the year.

FUEL OIL.

Oil burners have been installed at the machine shop, shipsways, on dredge *Gopher* (A No. 3) and on clapet No. 9. The results have been very satisfactory, though the new fuel has not been in use sufficiently long to enable accurate figures to be compiled on comparative cost of operation. Arrangements are being made to fit practically all plant with oil burners.

MISCELLANEOUS.

Material has been received for six sand barges, which are to be erected for use in connection with lock construction. Temporary track has been laid to the erecting yard (located near the La Boca lumber yard), though the assembling of parts has not yet been begun.

Clapet No. 11 was fitted with derrick, boom, and hoisting machinery, and placed in commission as a wrecking barge. Sunken French dredge No. 20, lying in the channel near the new wharf, is being dynamited and the scrap taken to sea and dumped. To date about 250 tons of material have been wrecked and disposed of.

During the latter part of May, a loaded lighter belonging to the Panama Railroad Company sank in the basin alongside the new

wharf, and the wrecking crew was transferred to the railroad company to raise the sunken barge.

The launch *Balboa* (which was transferred from the Pacific lock to the Colon dredging division) was dismantled, and the hull and internal machinery were loaded on flat cars for shipment to Colon.

Many small repairs and manufacturing jobs have been done for other divisions, for the Panama Railroad, the torpedo flotilla, and for the steamship companies whose vessels make port at La Boca.

Surveys, Maps, etc.

The work of running a duplicate line of precise levels across the Isthmus was authorized on February 24, and request made upon the Mississippi River Commission for the temporary transfer of two precise levelmen and outfits. Prior to their arrival on the Isthmus special bench marks were designed and manufactured, these monuments being placed and located by two field parties. Messrs. Thomas and Wolbrecht, levelmen, reached the Isthmus on June 2, and have run duplicate lines from the Atlantic end to a point near Bohio, and from the Pacific end to a point near Empire. Climatic conditions make work of this character very slow.

On September 4, 1907, the preparation of three general maps of the Isthmus (scales 1: 12000, 1: 40000 and 1: 100000) was authorized, and the work placed in charge of this division. At the close of the fiscal year the 1: 12000 map was practically completed; the 1: 40000 map was 90 per cent completed, and the 1: 100000 map projected. In order to prepare the 1: 100000 scale map along the lines contemplated, it will be necessary to make extensive surveys of the upper Chagres Valley. An estimate of the probable cost of this survey has been made and submitted.

During the early part of the year two original maps of the boundary line location were prepared and submitted in compliance with the requirements of the treaty with the Republic of Panama. Tracings were made and blueprints furnished to all concerned.

A number of minor surveys and observations have also been made.

In connection with the division of meteorology and river hydraulics, regular records of tides and rainfall have been kept.

Respectfully submitted.

D. D. Gaillard,
Major, Corps of Engineers, U. S. Army,
Member of Isthmian Canal Commission,
Head of the Department of Excavation and Dredging.

Lieut. Col. George W. Goethals,
Corps of Engineers, U. S. Army,
Chairman and Chief Engineer, Isthmian
Canal Commission, Culebra, Canal Zone.

PLATE 1.

PLATE 2.

OOKING SOUTH, JUNE, 1908.

CULEBRA CUT, LOOKING NORTH, FEBRUARY, 1908.

PLATE 4.

PLATE 5.

CULEBRA CUT, LOOKING NORTH FROM EMPIRE, MARCH, 1908.

PLATE 6.

OBISPO RIVER DIVERSION, LOOKING SOUTH, MAY, 1908.

PLATE 8.

OBISPO RIVER DIVERSION, LOOKING NORTH, MAY, 1908.

PLATE 9.

COMACHO DIVERSION TUNNEL, BAS OBISPO, MAY 2, 1908.

Diameter, 16 feet.

COMACHO DIVERSION TUNNEL, BAS OBISPO, MAY 22, 1908.

PLATE 11.

YARDS.

-four hours.

PLATE 12.

SLIDE NEAR NEW CULEBRA, CULEBRA DIVISION, APRIL, 1908. AREA OF SLIDE, 6,110 SQUARE YARDS.

Estimated amount of material in motion, 50,000 cubic yards. This slide started in the dry season and is composed of material from an old French dump.

PLATE 14.

LAS CASCADAS SLIDE, CULEBRA DIVISION, APRIL, 1908. AREA OF SLIDE, 5,433 SQUARE YARDS.

Estimated amount of material in motion, 100,000 cubic yards. This slide started in the dry season and extended back 230 feet from the edge of cut and to within 50 feet of the crest of the hill.

PLATE 15.

EXCAVATING NEAR SAN PABLO BEFORE A BLAST, FEBRUARY, 1908.

PLATE 16.

EXCAVATING NEAR SAN PABLO AFTER A BLAST, FEBRUARY, 1908.

EXCAVATING NEAR SAN PABLO AFTER A BLAST, FEBRUARY, 1908.

PLATE 17.

LOOKING NORTH FROM CAIMITO, JANUARY 31, 1908.

PLATE 18.

BEFORE THE BLAST AT CAIMITO, MARCH 20, 1908.

PLATE 19.

BLAST AT CAIMITO IN PROGRESS, MARCH 20, 1908. 25 HOLES, 19.5 TONS DYNAMITE. MATERIAL DISPLACED, 70,769 CUBIC YARDS.

Plate 20.

IMMEDIATELY AFTER EXPLOSION AT CAIMITO, MARCH 20, 1908.

SI

PLATE 21.

!SION, JUNE, 1908.

PLATE 22.

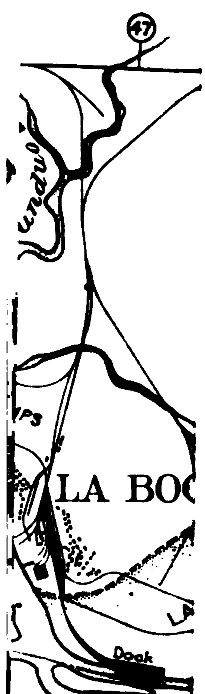
PLATE 23.

STEAM SHOVEL EXCAVATION AT MINDI, COLON DREDGING DIVISION, JUNE, 1908.

PLATE 24.

OLD FRENCH LADDER DREDGES WORKING IN THE NEW CHANNEL AT LA BOCA, JUNE, 1908.

SEAGOING SUCTION DREDGE "CULEBRA" PLACED ON BEACH AT NAOS ISLAND, BAY OF PANAMA, JANUARY 9, 1908, THAT THE BOTTOM MIGHT BE SCRAPED AND PAINTED, AFTER A TRIP OF 12,000 MILES FROM SPARROWS POINT, MD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APPENDIX B.

REPORT OF MAJ. WM. L. SIBERT, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSON, HEAD OF THE DEPARTMENT OF LOCK AND DAM CONSTRUCTION.

CULEBRA, CANAL ZONE, *July 1, 1908.*

SIR: I have the honor to submit the following report of work done by the department of lock and dam construction during the fiscal year ending June 30, 1908:

The permanent organization of this department had not been completed at the beginning of the fiscal year. The work of constructing the Gatun locks and dam was being done by Mr. William Gerig, division engineer, Colon construction division, in addition to his other work. The work connected with the construction of the La Boca locks and dam was being performed by Mr. William G. Comber, division engineer, La Boca construction division, in addition to his other work. On May 17, 1907, Mr. S. B. Williamson reported for duty, and on July 15 he was appointed division engineer, La Boca lock construction division. Maj. Chester Harding was employed and assigned to duty August 7, 1907, as division engineer, Gatun lock construction division. The permanent organization for the larger part of the fiscal year was as follows: William Gerig, division engineer, Gatun dam division; Chester Harding, division engineer, Gatun lock construction division; S. B. Williamson, division engineer, La Boca lock construction division, until December 17, 1907, and from that date to the end of the fiscal year division engineer, Pacific lock and dam construction division; William G. Comber, division engineer, La Boca dam construction division until a change of project eliminated the La Boca dams, and Mr. Comber's duties connected with the lock and dam department thereafter were confined to surveys, etc.

GATUN LOCKS.

[MAJ. CHESTER HARDING, division engineer.]

This work, as previously stated, was in local charge of Mr. William Gerig, division engineer, until August 7, 1907, and from that date until the end of the fiscal year under Maj. Chester Harding, division engineer.

The work of determining the character of the material underlying the Gatun locks was continued throughout the fiscal year. The borings in existence prior to the beginning of the year only extended a few feet below the foundation of the lower lock of the series, and it was decided to bore another series of holes, extending at least 50 feet below this foundation, with a view of determining with greater definiteness the character of the underlying material, and for the pur-

pose of fixing the thickness of the various strata under the lock foundations. As these holes were drilled, the drillers continued to report a layer of black sand, a similar layer having been reported under the northern part of the lock foundations. While it was necessary to chop this material, it was washed up after chopping apparently as sand. The persistence of this stratum led me to believe that it might be water bearing, so on December 5 I instructed Maj. Chester Harding as follows:

In boring the last holes at Gatun, I would like to have experiments made with a view of determining the amount of clay, or other cementing material, that is found along with the black sand. This might be obtained by catching all the water corresponding to a definite length of hole and allowing it to settle. If you have not done it, please pump out one of these holes and try to determine whether this material is fully saturated with water, and if so, the amount of water that can be pumped out of it in a definite time.

Major Harding found the material in question to be water bearing, and was then directed to dig a test pit and make a systematic series of seepage tests, taking the various water levels in different holes as affected by pumping. He found the black sand to be a soft sandstone. He tested the bearing capacity under actual load of this soft sandstone, as well as that of the argillaceous sandstone mixed with tufa underlying this soft sandstone.

The strata underlying the lock foundations are shown on Plate 41; the top stratum, designated "argillaceous sandstone," is quite impervious, except where fissured; the underlying "conglomerate" is to some extent water bearing; it is also fissured; the "soft sandstone" is water bearing and fissured; and the "argillaceous sandstone mixed with tufa" is water bearing where the tufa predominates.

Water rose in the drill holes after the soft sandstone was encountered, and on the 20th of January the hydraulic grade line, as indicated by water surface in holes, was as shown on Plate 41. The test pit was kept unwatered as it was dug, and the effect on the surrounding ground water will be noted on Plate 41, referred to above. The water was lowered 8.8 feet in hole No. 681, 1,250 feet away from the test pit, and the level of water in holes as much as 2,000 feet away was affected by the unwatering of the test pit. The hydraulic grade lines of January 20, 1908, when pumping in test pit was commenced, and March 13, 1908, when pumping ceased, are shown on Plate 41.

By your direction, a detailed report of these investigations was made to you through this office by Major Harding on July 23, 1908.

The effect of pumping out the test pit on the water levels in the surrounding holes indicates, to my mind, that the water passed through small crevices in the rock, rather than generally through the material, and that since these crevices are probably due to volcanic action the depth of them can not be determined. This state of facts was unknown before, and while it has delayed the design of the locks, it does not impose, it is thought, any condition that can not be fully met in the design.

LOCK EXCAVATION.

The total amount of material excavated from the lock site during the fiscal year was 1,769,115 cubic yards, of which 190,013 cubic yards were added to the rock fill at the south toe of the dam, where it crosses the old bed of the Chagres and the French Canal. 694,324 yards were deposited immediately to the west of the lock site as

a construction fill, on which will be placed the plant for handling concrete material for lock construction, and the remainder was delivered to the Panama Railroad in the Gatun yard and used in the fill on the relocation south of Gatun.

Accompanying this report are drawings (Plates 42, 43, 44) giving three cross sections in each lock chamber, showing in each section the original surface of the ground, the state of the excavation on July 1, 1907, the amount excavated during the fiscal year, and the amount remaining to complete the excavation.

The excavation thus far made has not required other drainage than that by gravity through a small ditch out from the north end of the excavation into the east diversion. This ditch drains the excavation to level plus 8. A pumping plant has been ordered, and in part received, for pumping the drainage of levels lower than plus 8 from a sump dug for the purpose at the south end of the locks. Studies have been made and a definite decision reached as to the method of excavating the north end of the lower lock and for excluding water from the excavation of the lower lock chamber by a cofferdam. The designs for this cofferdam have been studied and are complete. Studies have been made of forms for the lock walls and have reached a point where further progress is impracticable until the foundation plan and wall sections are determined.

In addition to the actual work of excavation, preparatory and incidental work have also been accomplished. Detail plans have been prepared for a material-handling plant, and a local repair shop has been erected and put in operation.

The following is a table showing the excavation, by months, number of shovels, rainfall, etc.:

Report, by months, of excavation for year ending June 30, 1908.

Month.	Quantity.	Average number of shovels at work.	Average per day per shovel.	Maximum daily average per month for single shovel.	Rainfall.	Cost per cubic yard of excavation for each month.
1907.	*Cu. yds.*				*Inches.*	
July	59,537	3.0	763	802	11.12	$0.72
August	78,357	3.63	800	900	16.37	.51
September	87,423	4.21	866	1,134	8.66	.56
October	136,777	5.00	1,013	1,140	8.66	.38
November	121,635	4.92	1,031	1,142	14.27	.43
December	160,796	5.00	1,286	1,482	5.53	.3163
1908.						
January	198,567	5.65	1,317	1,477	3.18	.2746
February	176,291	5.83	1,259	1,367	1.29	.3238
March	219,561	6.42	1,315	1,574	2.81	.2861
April	225,467	6.92	1,308	1,525	1.47	.2730
May	166,410	5.76	1,156	1,390	17.30	.3431
June	143,295	4.78	1,165	1,329	13.33	.3861
Total	1,769,115	5.01	1,142	....	108.99	....

Number working days in year		305
Average per day	cubic yards	5,800
Number shovel days in year		1,549
Average per day per shovel	cubic yards	1,142
Total number locomotive days		2,867
Average number locomotives per day		9.4
Average number cars on hand:		
L. W. D.		80
O. D. since March		25

Photographs showing progress of the lock excavation are attached. (Plates 30, 31, 32.)

STONE FOR CONCRETE.

It was decided before the beginning of the past fiscal year that the stone for the concrete would be quarried at Porto Bello, about 20 miles east of Colon. On December 1 Major Harding placed Capt. Horton W. Stickle in local charge of this work.

A shipping wharf has been constructed, together with numerous storehouses. A gravity concrete dam across El Mango Creek has been built, which impounds 27,000,000 gallons of water. An office building, six labor barracks, bachelor, and other quarters have been erected, and a sewerage system has been installed.

One steam shovel is at work, the quarry plant is being installed, and the development of the quarry is well under way.

SAND FOR CONCRETE.

A survey party has been at Nombre de Dios, 40 miles from Colon, since May 3, charged with determining the extent and location of sand deposits at that place, making a hydrographic survey of the harbor, and a survey of the village and vicinity. One million yards of sand have been located, and recommendation for the adoption and development of a project to secure sand for the Gatun locks at that place has been made.

GENERAL.

In connection with handling the concrete material, requisitions have been submitted for 3 tugs, 1 stern-wheel towboat, 14 stone barges, and 1 30-foot navy cutter. Two tugs and the cutter have been delivered and are in service. The hull for the stern-wheel towboat has been delivered and is under erection. Requisitions have also been submitted and approved for material to construct a 1,200-foot wharf near dock 14, some of which material is now being received.

GATUN DAM.

[WILLIAM GERIG, division engineer.]

The work during the fiscal year has been confined to digging the spillway, the construction of the rock fills along the north and south toes of the dam, cleaning out the old bed of the Chagres and the French canal, to preliminary work, and to investigations as to the material underlying the dam, and as to the location of suitable material out of which to construct the dam.

SPILLWAY.

During the fiscal year 918,920 cubic yards of material have been excavated in the spillway. This channel has been made 300 feet wide, the elevation at its bottom at the south end is plus 10, thus preserving a layer at least 15 feet thick of compact argillaceous sandstone overlying the conglomerate rock below.

The excavation of the spillway, in so far as its use as a diversion channel for the Chagres River is concerned during the construction

of the main dam, is nearing completion; it is expected to complete the excavation on or before September 1.

This excavation was started during the wet season, and great difficulty was encountered in maintaining tracks. The following table gives the history and cost of this excavation:

Report, by months, of excavation for year ending June 30, 1908.

Month.	Quantity.	Average number of shovels at work.	Average per day per shovel.	Average per month for shovels.	Rainfall.	Cost per cubic yard of excavation for each month.
1907.	*Cu. yds.*				*Inches.*	
July	14,628	1.83	423	10,971	11.12	$1.0558
August	26,866	2.00	498	13,433	16.37	.7526
September	36,315	2.00	757	18,156	8.66	.6204
October	40,286	2.00	745	20,118	8.66	.5492
November	40,987	2.00	554	20,493	14.27	.5882
December	69,756	2.00	1,395	34,878	5.53	.3826
1908.						
January	98,588	3.00	1,264	32,862	3.18	.3841
February	106,506	3.75	1,183	28,401	1.29	.3596
March	155,087	4.50	1,313	34,452	2.81	.2726
April	147,989	5.00	1,184	29,597	1.47	.3331
May	100,837	4.40	908	22,290	17.30	.4617
June	101,656	3.50	1,117	29,045	13.33	.3855
Total	938,901	2.95	1,043	31,827	103.99	.4069

Number working days in year	305
Average per day ..... cubic yards	3,078
Number shovel days in year	900
Average per day per shovel ..... cubic yards	1,043
Total number locomotive days	1,726
Average number locomotives per day	5.7
Average number cars on hand	28.33

A photograph showing progress of the spillway excavation is attached. (Plate 33.)

FILLS AT TOES OF DAM.

A trestle was constructed along the south toe of the dam, except across the west diversion, for use in making a rock fill. In this toe have been placed 36,669 cubic yards of Bas Obispo rock and 329,257 cubic yards of material, largely rock, excavated from the spillway and the lock site. A trestle was also constructed along a portion of the north toe of the dam, from which 175,140 cubic yards of material, excavated from the spillway, was wasted.

PRELIMINARY WORK.

An area of over 20 acres has been cleared on Gatun and spillway islands, most of it grubbed and burned. The native huts in the village of Gatun have been torn down and the old Catholic church with its concrete foundations has been moved. Two lines of sheet piling have been driven across the old Chagres, for the purpose of forming coffer dams for unwatering that portion of the bed of the stream underlying the dam. It is a part of the programme to pump out that part of the bed and remove all unsuitable material and make a suitable connection between the underlying material and the dam proper.

Under the general direction of Division Engineer William Gerig, Assistant Division Engineer C. M. Saville has carried on investigations for the purpose of, first, finding suitable material for use in constructing the earthen dam; second, determining the nature of the foundations of the dam and spillway, and third, by means of a model dam studying the suitability and stability of material as well as construction methods for application to the proposed Gatun dam.

In locating suitable material for constructing the earthen dam, soil surveys were made by wash drill borings in the valley of the Chagres near its junction with the west diversion and in the Gatuncillo valley south of the dam. The facts developed by these surveys, together with previous borings, indicate that there is available, within 1½ miles of the dam, suitable material in sufficient quantity for the building of the dam.

In the investigation for the dam and spillway foundations, a line of borings along the center line about 200 feet apart and two test pits, one on Gatun Island and the other in the spillway were started. The test pit on Gatun Island is 20 feet square, and the one at the head of the spillway is 12 feet square. The material encountered in the test pit in the spillway is rock and is a formation somewhat similar to that underlying the locks at Gatun. This corroborates the earlier records. The records of the test pit on Gatun Island show a brown sandy clay from the surface to about plus 1; from plus 1 to minus 2½ a bluish yellow clay; from minus 2½ to minus 30 a blue sandy clay; from minus 30 to minus 40 a blue clay with a mixture of decayed vegetation, and below that apparently a sea deposit composed of dark-blue clay with a large proportion of shells. The material encountered below minus 30 is apparently practically impermeable, while above that there was a slight infiltration of water into the pit, but not more than would be expected through excellent dam material.

It has been decided, as an extra precaution, to drive a row of triple lap sheet piles down into the more impermeable stratum under the core of the dam.

The filtration tests and tests with the experimental dam as ordered by you have been continued. For tests of frictional resistance of various soils filtration tests have been made in the tanks, and tests have also been made of various rocks found in the excavation to determine their resistance to percolation of water and to abrasion, if subjected to a high velocity of water. Mechanical analyses of various soils are under way in connection with filtration tests of various materials and their resistance to flow.

A model dam has been built of material similar to that to be used in building the actual dam. This model dam was built by means of a centrifugal pump taking material from a barge in which it was brought up the river. The method of building was to discharge all material into the dam at the downstream or north toe, and allow it to grade itself toward the upstream face. This dam was built to one-twelfth scale and tested with a corresponding head of water, and the results were exceedingly satisfactory. The plan of procedure was to build this dam out of different grades of material thought to be good and to vary its construction: first, to build a dam by pumping the material into it from the downstream side only; and second,

to build one by pumping the material into it from both sides, allowing the finer material to settle in the central portion. The first experiment is complete and the second is under way.

PLANT CONSTRUCTION.

Three 20-inch pipe-line suction dredges were delivered knocked down, under contract, by the Maryland Steel Company. They were erected at the dry dock of the Colon dredging division. No. 82 was launched on December 19 and sent to Gatun in March, although not entirely completed. This dredge started work in the Chagres River pumping the soft material out of the bed on the 1st of April. She was sent back to the shops for overhauling and completion on June 12. No. 83 was completed about that time, and No. 85 is launched, but not entirely completed.

CHANGE OF LOCATION OF LOCKS AND DAMS ON THE PACIFIC SLOPE.

At the beginning of the fiscal year the adopted project contemplated the construction of one lock at Pedro Miguel and two at La Boca, and of two dams at La Boca, one connecting Corozal and Sosa Hills, and the other San Juan and Sosa Hills. The plan of dam construction was to build rock ridges and construct an earthen dam between these ridges. The Culebra division undertook to construct these rock ridges out of waste material from the Culebra Cut, and in the performance of this work constructed trestles along the toes of the dam connecting Corozal and Sosa Hills. Great difficulty, however, was experienced in making these fills. The material underlying continued to slip, disrupting the trestles and at times overturning trains. Finally authority was obtained from you to commence investigations with a view of finding a new location for the La Boca locks and dams somewhere between Pedro Miguel and the sea. In giving this authority you suggested that a trial be made at Miraflores. In pursuance of this authority, Mr. S. B. Williamson, division engineer, was instructed to commence borings at Miraflores and to follow the old center line of the French canal with borings 1,000 feet apart for a certain distance; then to incline his line of borings toward Aguadulce Hill, with a view of developing the territory between Miraflores and Aguadulce Hill if the preliminary borings gave any encouragement. The former chief engineer, John F. Stevens, in his investigations with a view of locating the locks and dams on the Pacific slope at Aguadulce Hill, had had explored thoroughly the territory immediately south of that to be explored by Mr. Williamson. These latter explorations led to the development of suitable sites for locks between Miraflores and Cocoli Hill. Cocoli Hill joins Aguadulce Hill. They also developed the fact that rock foundations existed for dams connecting these locks to the hills on either side.

Mr. Williamson prepared a report embodying the result of his investigations and studies. This was forwarded with a report by me, dated December 3, 1907. In both of these reports it was recommended that the two locks to be built at La Boca be built between Miraflores and Cocoli Hill, and in my report that the same be connected to the hills on the east and west by concrete dams founded on rock.

A portion of these investigations was made during my absence on leave and under your immediate direction.

After the above reports were made further investigations indicated that three locks could be built at Miraflores, and a report, dated January 31, 1908, was submitted to you, setting forth the relative cost of constructing and maintaining all of the locks on the Pacific slope at Miraflores, and the project for building two there and one at Pedro Miguel, together with the relative advantages and disadvantages to navigation presented by the two projects.

The greater part of the construction work done under the old project was useful work. It has been decided to obtain the stone for the locks at Miraflores from the prior lock site at La Boca, and the preliminary work done at the latter site is practically all useful work in the development of the quarry at that place. The trestles built between Corozal and Sosa Hill will be utilized in hauling stone and sand from La Boca to the lock site at Miraflores. The drainage ditch dug between Ancon and Sosa Hills becomes a necessary part of the present project, acting as a diversion channel diverting from the sea-level portion of the canal water coming down the Curundi River.

In making the investigations with a view of relocating the locks, 23 test holes were bored along the channel between Aguadulce and La Boca to determine the nature of the material to be dredged between these points. The aggregate depth of these holes is 1,225.2 feet, of which 1,102.7 feet were spudded and 122.5 feet diamond drilled.

Work on the New Project, Pacific Slope.

[S. B. Williamson, Division Engineer, Pacific Lock and Dam Division.]

PEDRO MIGUEL LOCKS AND DAMS.

Borings.

In the past year 14 additional test holes were bored at the lock site, aggregating 875.2 feet in depth, of which 90.8 feet were wash-drill and 784.4 feet diamond-drill borings. In all cases the borings were driven through solid rock to a depth of at least 25 feet below the proposed foundations.

Construction.

It was more economical and expedient for the Culebra division to excavate the lock site to reference plus 40 in connection with their adjacent work. The amount of material moved by them is 1,071,696 cubic yards.

In June, 1908, the lock and dam division began operating one shovel at the lower end of the site and the construction of a railway track connecting the work at Pedro Miguel and Miraflores; also grading for a track west of and approximately parallel to the Pedro Miguel site. Both are to be used as dump tracks and for transporting materials and supplies. It is proposed to install three more shovels on this work as rapidly as possible. Following is total of work performed:

Grading for tracks	cubic yards	6,335
Track laid	linear feet	8,000
Track surfaced	do	2,050
Excavated at lock site:		
In prism	cubic yards	6,832
Accessory	do	661

MIRAFLORES LOCKS AND DAMS.

Borings.

While conducting the examinations previously mentioned, 266 holes were bored on and in the vicinity of the sites finally selected for the locks and dams, the aggregated depth being 18,181.2 feet, of which 9,580 feet were wash drill, 8,168.4 feet diamond-drill borings, and 432 feet open test pits extending to the rock surface. All borings were carried into the solid rock to a minimum depth of 25 feet below the proposed foundation of the walls.

Generally speaking, the upper locks and dams will be founded on hard limestone and the lower locks and approach walls on argillaceous sandstone (varying slightly in hardness), thought to be suitable in every respect for foundations.

Construction work.

The work of construction was begun at Miraflores the latter part of December, 1907, and consisted, primarily, in clearing the sites, making detailed topographical surveys, and laying out and constructing tracks incident to the work of excavating. Two steam shovels were installed during January, 1908, and additional shovels put to work from time to time since. The average number of shovels working since January is 5 plus, and the total number working at present is 5, 2 of which are on accessory work. A greater portion of the lock site is low ground, which necessitates depositing the excavated material in fills on both sides, to be occupied by the erection plant. These fills will also form a portion of the back filling required.

The site of the earthen dam required on the west for protection against the Cocoli River has been cleared and a greater portion of the stumps, roots, and surface soil removed.

Total quantities are as follows:

Clearing	acres	166
Excavation in prism of locks	cubic yards	297, 476
Excavation out of prism, accessory	do	44, 310
Tracks laid and surfaced	linear feet	45, 900
Trestle built	do	1, 390
Stripping site of dam	cubic yards	3, 592

Report, by months, of excavation for year ending June 30, 1908.

Month.	Quantity.	Average number of shovels at work.	Average per day per shovel.	La Boca rainfall.	Rio Grande rainfall.	Cost per cubic yard of excavation for each month.
1908.	*Cu. yds.*			*Inches.*	*Inches.*	
January	7, 203	1.00	300	0.21	0.75	$3.40
February	38, 661	3.00	539	.55		.7765
March	67, 963	3.50	746		.14	.6095
April	92, 261	4.50	820	.76	2.00	.5665
May	71, 335	5.75	496	8.65	14.26	.7285
June	68, 691	3.81	695	4.98	11.08	.9022
Total	346, 114	3.61	774	15.15	28.23	.7575

Number of working days in year	150
Average per day	2, 307
Number of shovel days	542
Output per day per shovel	774
Locomotive days	1, 820
Average number locomotives per day	12

A photograph showing progress of the Miraflores locks excavation is attached. (Plate 40.)

COCOLI DIVERSION.

Included in the present project is a diversion channel about a mile and a quarter west of the lock site, to provide for the overflow from the Cocoli River and the lake to be formed between Pedro Miguel and Miraflores. The following work has been done during the year:

Borings.

Six holes, aggregating 194 feet in depth, were driven, 174 feet being spudded and 20 feet diamond drilled.

Construction work.

The site has been cleared of trees, stumps, and underbrush, a wagon road built from the lock site, and a portion of the excavation made by means of scrapers. Total quantities are as follows:

Clearing	acres	46
Building roads	linear feet	6,000
Excavating diversion	cubic yards	19,442

STONE FOR CONCRETE.

About 2,000,000 cubic yards of broken stone are required for concrete, and during the year careful examinations have been made of Cocoli Hill, the hills north of Corozal and east of the Panama Railroad, and Sosa Hill, as being the only promising available sites for a quarry. After due consideration of the cost of stripping, quarrying, transportation, and contingencies, together with the amount and quality of the stone, Sosa Hill at La Boca has been selected. There has been no work at the quarry except that done in the early part of the year for the proposed La Boca locks. This work, however, will facilitate opening a quarry, as it is mainly stripping.

SAND FOR CONCRETE.

Preliminary and detailed examinations have been made at various points along the Pacific coast in the vicinity of Panama for sand suitable for concrete. As a result, Point Chame has been selected, there being an abundance of sand of good quality located in a protected bay.

The work done so far has been clearing, making surveys, sinking test pits and borings to ascertain the amount and quality of the deposit, and collecting samples.

Plans and specifications were prepared for six steel barges for towing sand. The barges have been delivered knocked down, and are now being assembled at the La Boca shipyard. A tug for towing the sand barges has been purchased and delivered at La Boca.

OFFICE WORK.

A number of maps, profiles, and estimates were made in determining the new location for the Pacific locks and dams, all available

sites being considered. Numerous studies have been made of the erection plants for the Miraflores and Pedro Miguel locks, for which a plan has been adopted and specifications are in course of preparation. Plans of the quarrying and crushing appliances to be installed at the La Boca quarry, with specifications, are practically completed. Studies of the methods for handling and transporting sand are in progress. The usual routine clerical and office engineering work has been performed. The latter includes the preparation of plans for shops, storehouse, and power house, maps, profiles, sections, etc.

SURVEYS.

[Mr. W. G. COMBER, division engineer.]

Prior to the abandonment of the La Boca lock and dam project, on December 20, 1907, Mr. Comber was division engineer of the La Boca dam construction division, in addition to other work. In this capacity there was carried on under his direction, by Mr. C. M. Saville, extensive drill and test pit explorations on the sites of the Sosa-Corozal and Sosa-San Juan dams. Two test pits were also sunk on the site of the proposed San Juan spillway.

The drainage ditch was extended from the beach between Sosa and Ancon hills to the La Boca branch of the Panama Railroad.

SURVEYS.

Surveys were made of the territory to be flooded (under the original lock and dam plan), the lines being carried up to the 85-foot contour or above.

The work of running a duplicate line of precise levels across the Isthmus was authorized on February 24. Such line has been run from the Atlantic end to near Bohio and from the Pacific end to near Empire.

On September 4, 1907, the preparation of three general maps of the Isthmus (scales 1:12000, 1:40000, and 1:100000) was authorized and the work placed in charge of Mr. W. G. Comber. At the close of the year the 1:12000 map is practically completed, the 1:40000 map is 90 per cent completed, and the 1:100000-scale map projected. In order to prepare the 1:100000-scale map along the lines contemplated, it will be necessary to make extensive surveys of the upper Chagres Valley. An estimate of the probable cost of this survey has been made and submitted to you.

During the early part of the year two original maps of the boundary-line location were prepared and submitted in compliance with the requirement of the treaty with the Republic of Panama. Tracings were made and blueprints furnished to all concerned.

ELECTRICAL DESIGNS.

[EDWARD SCHILDHAUER, electrical and mechanical engineer.]

In addition to the routine work the following studies, plans, drawings, and specifications were made:

Study, design, and specifications for machine shop and temporary generating station to supply power to permanent electric apparatus before the Gatun handling plant generating station is in operation.

Drawings and specifications for turbo-alternators and connections for material-handling plant power station at Gatun.

Studies of material-handling plant at Gatun from barges to locks.

Drawings and specifications for boiler-room equipment of Gatun and Miraflores power stations.

Specifications for motor to drive high-pressure turbine pump.

Specifications for boiler, stack, and breechings for the addition to the Porto Bello power plant.

Studies for the Miraflores and Pedro Miguel material-handling plant.

Studies of the water-turbine plants for Gatun and Miraflores, using as a subsidiary steam plant the apparatus bought for the respective handling power plants.

Studies of controlling operations for the passage of ships through the locks by means of a central interlock control station.

Specifications for generating set and materials and lay out of wiring for stern-wheel towboat.

MASONRY DESIGNS.

[L. D. CORNISH and H. F. TUCKER, designing engineers.]

Completed the preliminary designs and made general plans, sections, and estimates on different types of locks on both Atlantic and Pacific slopes, as follows:

General plans for 100-foot locks:
- 1 lock at Pedro Miguel.
- 2 locks at Pedro Miguel.
- 1 lock at Miraflores.
- 2 locks at Miraflores.
- 1 lock at La Boca, upper location.
- 1 lock at La Boca, lower location.
- 2 locks at La Boca.
- 3 locks at Miraflores.
- 3 locks at Gatun.

Estimates for 100, 110, 115, 120, and 125 foot locks:
- 1 lock at Pedro Miguel, with and without inverts.
- 2 locks at Pedro Miguel, with and without inverts in upper locks.
- 1 lock at Miraflores.
- 2 locks at Miraflores.
- 1 lock at La Boca, upper location.
- 1 lock at La Boca, lower location.
- 2 locks at La Boca.
- 3 locks at Miraflores.
- 3 locks at Gatun, with and without invert in upper lock.

Also estimates for two projects for locks on the Pacific slope, involving a combination of one lock at Pedro Miguel with two at Miraflores in one project, and three locks at Miraflores in the other project.

Made plans and estimates of numerous studies for Gatun locks with various types of foundation and various studies of lock-filling system.

METEOROLOGY AND RIVER HYDRAULICS.

[R. M. ARANGO, division engineer.]

RIVER HYDRAULICS.

Gauging of the Chagres River has been continued throughout the year at the following stations: Alhajuela, Gamboa, Bohio, and Gatun. In addition, gauging stations have been maintained on the

Gatuncillo and Trinidad rivers just above the influence of tide water. Gaugings at Gatun have not been a success, the river flow at that place being materially affected by tidal action, and reliance has been placed upon the Bohio, Gatuncillo, and Trinidad stations in estimating the total discharge at Gatun.

During the early part of the dry season, 1907–8, Alhajuela station showed a higher discharge than Bohio, and an investigation of the relative discharges at Alhajuela, Gamboa, and Bohio was made.

In addition to the above-mentioned stations authority was obtained for the establishment of flood-warning station at Vigia.

The detail of this hydrographic work is in the permanent files, and available in connection with any investigations necessary in connection with the water supply for the canal.

METEOROLOGY.

The object of the meteorological work is to collect meteorological data for the use of the engineering and sanitary departments of the Isthmian Canal Commission. To supply data to the United States Coast and Geodetic Survey, United States Weather Bureau, bureau of ocean meteorology, International Association of Climatologists and Seismologists, Panama Railroad and Steamship Company, the captains of vessels touching at the ports of La Boca and Cristobal, and likewise to supply data for the correction and adjustment of the instruments used by the navigating officers of such vessels.

This section maintains three first-class and three second-class meteorological stations; also thirteen rainfall stations.

Special fog observations were begun on February 1 at Cristobal, Gatun, Bohio, Bas Obispo, Alhajuela, Culebra, Pedro Miguel, and Ancon. Record of these observations is shown on the following table:

Hours of duration of fogs in canal prism, 1908.

Month.	Dense fogs.		Light fogs.		Total number of fogs observed.	Total duration.	Fogs observed but not timed.	
	Number observed.	Total duration.	Number observed.	Total duration.			Dense.	Light.
		h. m.		h. m.		h. m.		
February	6	26 45	14	49 55	20	76 40	....	5
March	2	6 15	10	39 10	12	45 25	3	10
April	11	52 5	7	29 20	18	81 25	5	15
May	30	124 40	48	135 45	78	260 25	8	22
June	22	58 30	57	169 50	79	228 20	7	18
Summary	71	268 15	136	424 0	207	692 15	23	70
Mean	....	8 47	....	3 7	....	8 21	....	....

It should be noted that these observations are largely in the dry season, during which season there are less fogs than during the wet season.

On April 1 there was transferred to the meteorological section all work in connection with tidal measurements at Cristobal and La Boca. These measurements were made in connection with the precise level line now being run across the Isthmus.

Authorization has been granted for a building on the western slope of Ancon Hill, to contain, in addition to the office of the division engineer, a seismographical station, and the Ancon meteorological observatory. Two B-O seismographs, recently purchased, will be installed in this building.

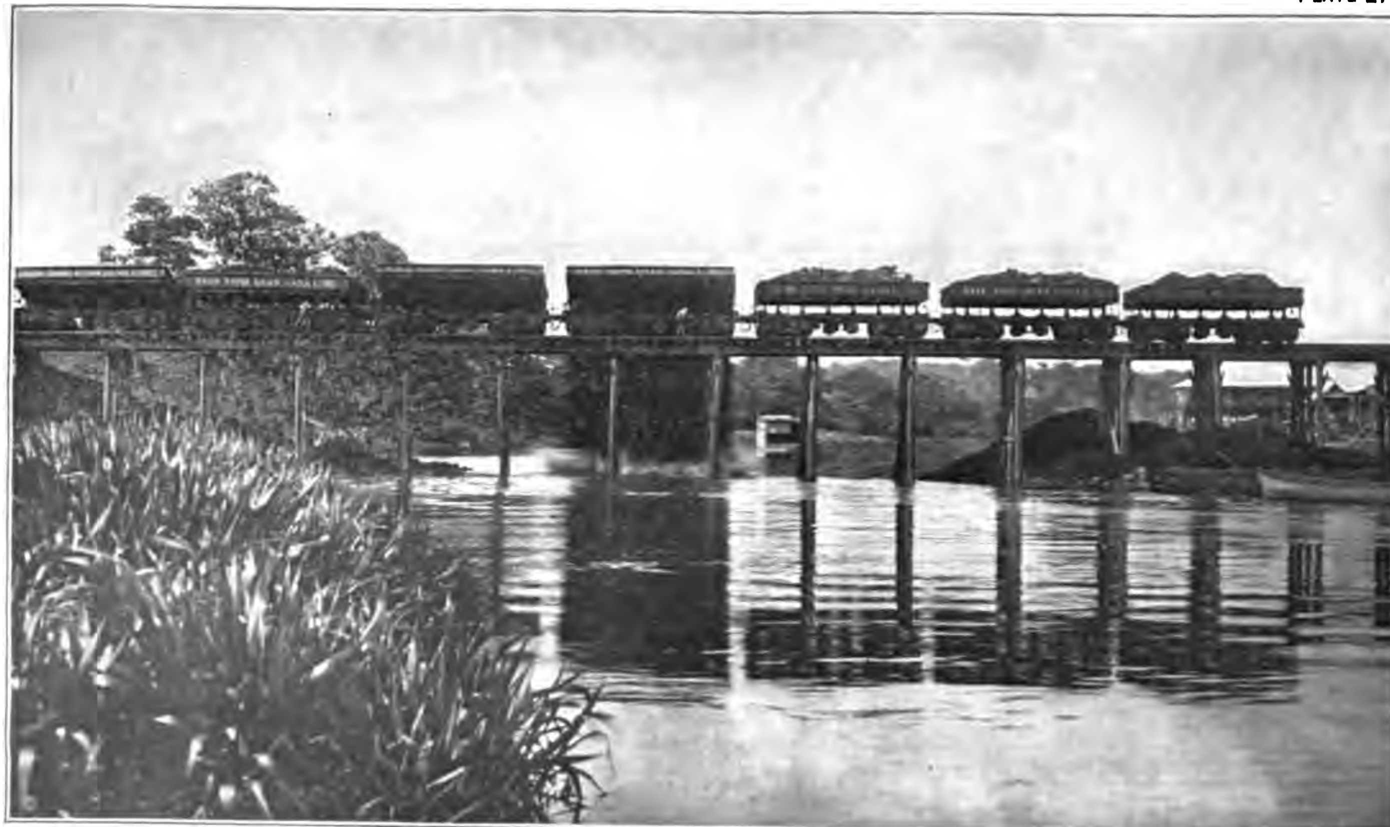
The detailed records of the meteorological section are of necessity voluminous and are in the files for use in the study of any problems with which they are concerned.

Respectfully submitted.

Wm. L. Sibert,
Major, Corps of Engineers, U. S. Army,
Head of the Department of Lock and Dam Construction.

Lieut. Col. Geo. W. Goethals, *U. S. Army,*
Chairman and Chief Engineer, Culebra, Canal Zone.

PLATE 27.



CLOSING OF THE CHAGRES RIVER AT GATUN, AUGUST 10, 1907.

CLOSING OF THE CHAGRES RIVER AT GATUN, DECEMBER 2, 1907.

TWENTY-INCH SUCTION DREDGE, CHAGRES RIVER AT GATUN.

PLATE 30.

EXCAVATING AT LOCK SITE, GATUN, LOOKING SOUTH, JANUARY, 1907.

PLATE 31.

PLATE 33.

PLATE 34.

PLATE 34.

PLATE 35.

THE CAMP, PORTO BELLO, FROM THE QUARRY, JUNE, 1908.

PLATE 36.

PEDRO MIGUEL LOCK SITE, LOOKING SOUTH, NOVEMBER, 1907.

Plate 37.

LOOKING NORTH FROM PEDRO MIGUEL LOCK SITE, MARCH, 1908.

LOOKING NORTH FROM PEDRO MIGUEL LOCK SITE, JUNE, 1908.

PLATE 39.

PLATE 40.

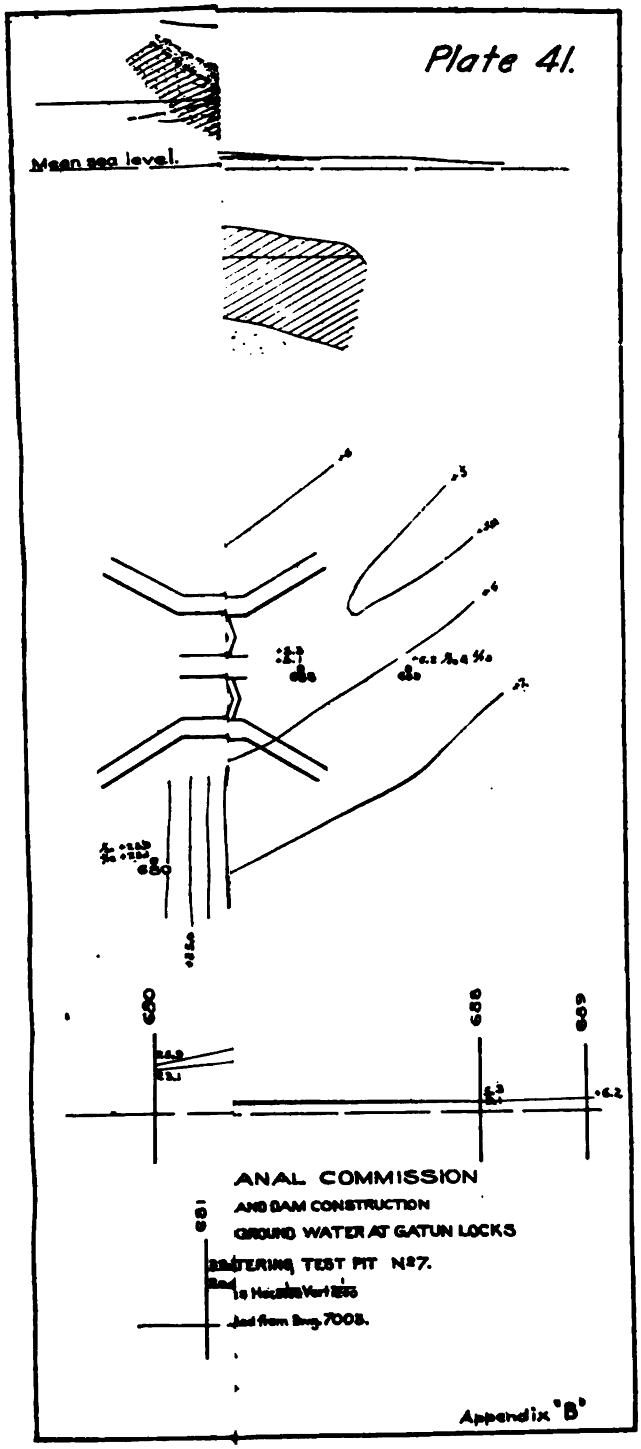
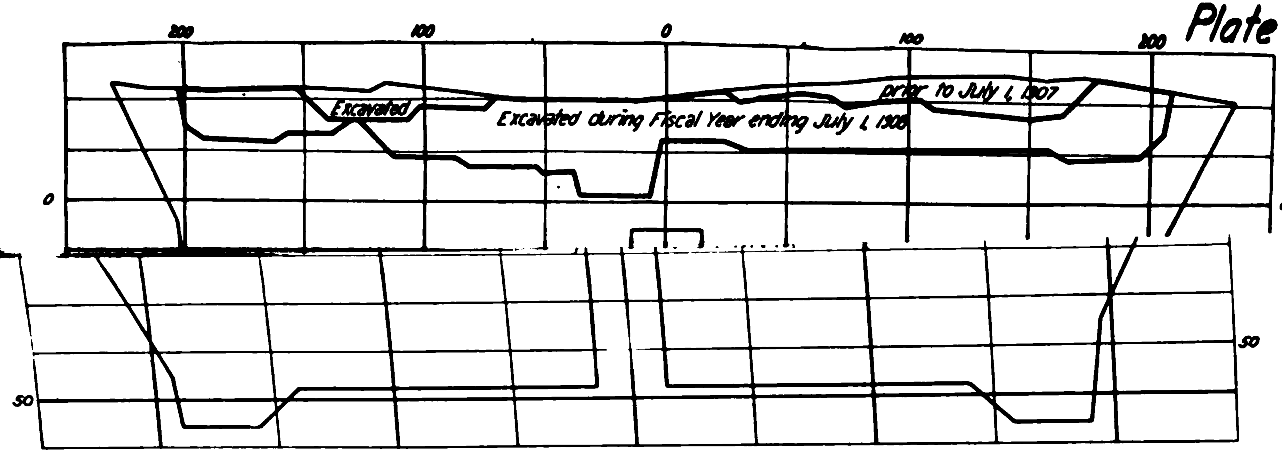


Plate 41.
Mean sea level.
680
680
688
680
688
609
+6.2
ANAL COMMISSION
AND DAM CONSTRUCTION
GROUND WATER AT GATUN LOCKS
TEST PIT No 7.
Dwg. 7003.
Appendix "B"

Plate 42.



MILE 7 + 00

ISTHMIAN CANAL COMMISSION

ATLANTIC DIVISION

SECTIONS SHOWING

PROGRESS OF EXCAVATION IN LOCK SITE

—— LOWER CHAMBER ——

Hor. 1:960 Scales 1:480 Vert.

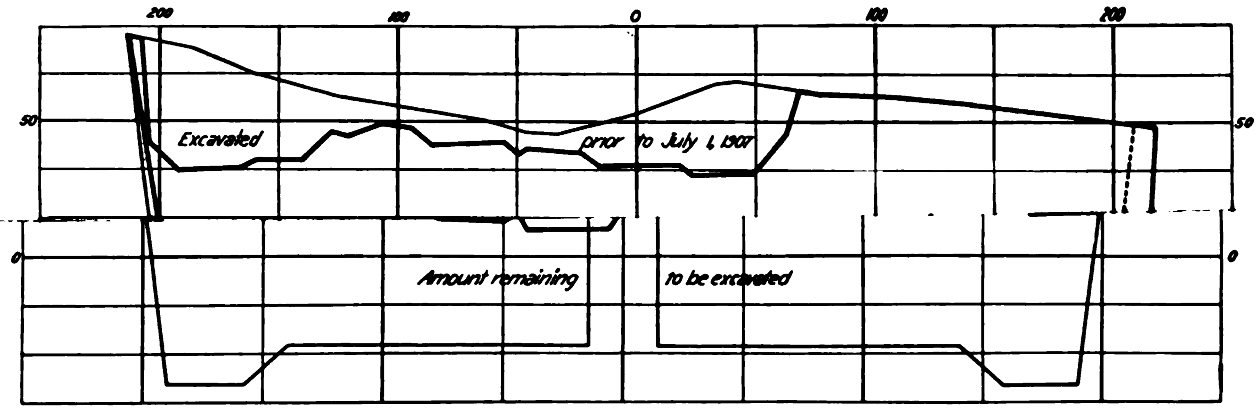
Major of Engineers

Ass't Division Engineer.

Gatun, C.Z. July, 1908.

To accompany Annual Report

Plate 43.



MILE 7+ 980

ISTHMIAN CANAL COMMISSION

ATLANTIC DIVISION

SECTIONS SHOWING

PROGRESS OF EXCAVATION IN LOCK SITE

—MIDDLE CHAMBER—

Hor. 1:960 Scales 1:480 Vert

Edwin Harding

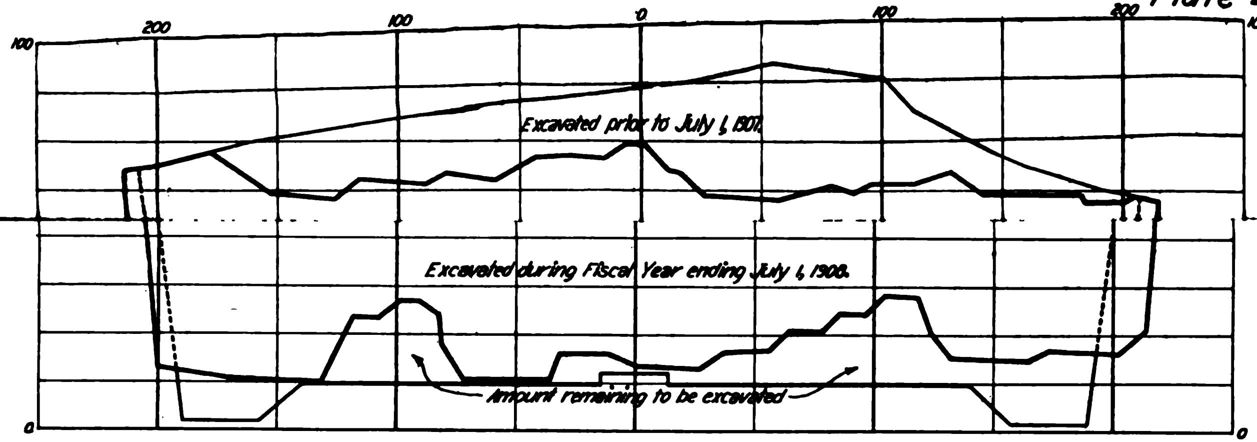
Major of Engineers

Ass't Division Engineer.

Gatun, C.Z. July 1908.

To accompany Annual Report

Plate 44.



MILE 7+2000

ISTHMIAN CANAL COMMISSION

ATLANTIC DIVISION

SECTIONS SHOWING

PROGRESS OF EXCAVATION IN LOCK SITE

—UPPER CHAMBER—

Hor. 1:960 Scales 1:480 Vert.

Chester Harding

Major of Engineers

Ass't Division Engineer.

Gatun, C.Z. July 1908.

To accompany Annual Report

APPENDIX C.

REPORT OF CIVIL ENGINEER H. H. ROUSSEAU, U. S. NAVY, MEMBER OF ISTHMIAN CANAL COMMISSION, HEAD OF THE DEPARTMENT OF MOTIVE POWER AND MACHINERY, MUNICIPAL ENGINEERING, AND BUILDING CONSTRUCTION.

CULEBRA, CANAL ZONE, *July 6, 1908.*

SIR: I have the honor to forward herewith report of operations and expenditures of the department of motive power and machinery, municipal engineering, and building construction for the fiscal year ended June 30, 1908.

On July 1, 1907, the organization of each division had been completed and the work of the divisions of municipal engineering and building construction was appreciably diminishing.

During the fiscal year covered by this report efforts in all three divisions have been principally concentrated on reducing the cost of work. Systems of cost keeping have been perfected in each division, and, as a result, keen rivalry between the different subdivisions exists at the present time, with a view to making the best showing in this respect. In addition, it has been found desirable in the division of building construction to further promote this condition by constructing certain type buildings by contract, the commission furnishing all material and the contractor all labor. Table accompanying this report shows that quarters for bachelors are being constructed for less than 8 cents per cubic foot and the standard 4-family quarters for less than 12 cents per cubic foot. A wide or further extension of construction by contract is not considered advisable on account of the more satisfactory results obtained at present from day labor.

Under circular order, issued by the chairman and chief engineer, dated April 12, 1907, the duties of the divisions of motive power and machinery and building construction were fixed as follows:

SUPERINTENDENT OF MOTIVE POWER AND MACHINERY.

He shall be charged, subject to the approval and direction of the chief engineer or supervisory engineer, as provided, with the proper maintenance and repair of all machinery used or provided in or about the construction of the canal, except floating equipment.

He shall issue instructions covering standard designs and methods for the guidance of all employees in charge of or connected with the machinery employed, as noted above.

He shall, from time to time, through the proper officials, give such instructions concerning the organization, discipline, size of force, and methods of execution of the different items of work under his charge as, in his opinion, may be necessary to secure the efficient and economical operation of his division.

He shall keep in his file a complete physical record of all machinery and equipment bought for or used in the construction of the canal, except floating

equipment, and shall also keep copies of all standard drawings pertaining to his division.

He shall design, or cause to be designed, all plans for improvements or additions to the mechanical devices of all shops, engine houses, and similar facilities.

He shall, through the proper officials, direct the operation of all shops (except marine shops), engine houses, and their accessories, and shall pass upon the qualifications of all stationary engineers and locomotive engineers and firemen, and will be responsible for the proper care and condition of all mechanical power and equipment.

He shall, through his chief clerk, be responsible for all clerical work of his division and shall make such reports covering same as may be ordered.

He shall aid the chief engineer or any supervisory engineer, as directed, in the construction and maintenance of any mechanical appliances, and, through an electrical engineer, render, in a similar way, aid on any electrical work.

MASTER BUILDER.

He shall have charge, subject to the approval and direction of the chief engineer or supervisory engineer, as provided, of the construction, whether by commission forces or by contract, of all buildings or specially designed structures erected for the use of the commission or of its employees.

He shall have charge of all reconstruction or heavy repairs on existing buildings or specially designed structures, the property of the commission.

He shall make requisitions, subject to the approval of the chief engineer, for all materials required in the construction of all buildings or other structures which may be authorized. He shall, personally and through the proper superintendents, foremen, and inspectors, exercise such supervision over all work in his charge as may be necessary to insure its prompt and economical completion.

He shall, through his chief clerk, be responsible for the correct execution of such clerical work, including reports, as may be necessary in conducting the business of this division.

The division of municipal engineering was established on July 19, 1904, in order to carry out the provisions of Article VII of the treaty between the United States and the Republic of Panama, whereby the United States is granted the right to construct, maintain, and operate all works "of sanitation, collection and disposition of sewage, and distribution of water in the cities of Panama and Colon" as "may be necessary and convenient for the construction, maintenance, operation, sanitation, and protection" of the Panama Canal and the Panama Railroad, cost of same, with interest, to be amortized within a period of fifty years by water and sewerage rates to be imposed and collected by the United States, said works to become the property of the cities of Panama and Colon at the expiration of that period. The surveys for the necessary waterworks and sewerage systems and paving in Panama and Colon were made and work started in the latter part of 1904. This work, as originally planned, has practically been completed. Similar improvements in the Canal Zone were the natural outgrowth of the above, and have been completed by this division, with the exception of minor additions and extensions which will be required with the progress of canal construction.

The work of the division of motive power and machinery will depend, largely, each year, upon the amount of dry excavation, and will practically come to an end upon the completion of same. The work now being performed by the division of municipal engineering will diminish year by year. Some increase in the capacity of the reservoirs may be found necessary from time to time; water and sewer pipes will have to be extended and renewed; and roads and walks will have to be constructed, repaired, and maintained. The cost of construction

and maintenance of roads is one of the largest items of expenditure in this division. The scour and irrigation resulting from the tropical downpours renders necessary, during the rainy season, a large force to keep drainage ditches open and roads in a state of repair. Comparatively little additional building construction is to be expected. During the fiscal year considerable work in the building line has been performed on account of the opening up of work on the Chagres division and at Porto Bello, and also to house employees engaged on lock and dam construction at Gatun and Miraflores. There has been a pressing demand for family quarters. This demand was largely reduced by the action of the commission at its one hundred and thirty-seventh meeting, held December 7, 1907, in accordance with which the commission will not construct new quarters for families of employees whose appointments date on and after January 1, 1908. Family quarters are available for about 25 per cent of the "gold" employees. The largest item of work in the future for the division of building construction will be maintenance and repairs, especially painting, as well as the renewal of portions of the structure of buildings caused by deterioration and decay. Considerable difficulty has been experienced in securing durable screening, but it is believed that this has been overcome.

The total number of employees at work in this department on July 1, 1907, and on June 30, 1908, was as follows:

Division.	July 1, 1907.			June 30, 1908.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Motive power and machinery	865	1,614	2,479	962	1,244	2,206
Municipal engineering	160	1,829	1,989	105	910	1,015
Building construction	1,044	3,083	4,127	326	1,040	1,366
Total	2,069	6,526	8,595	1,393	3,194	4,587

The total expenditures of this department during the fiscal year covered by this report are shown in the following table:

Division.	Labor.	Material.	Total.
Motive power and machinery	$2,170,707.90	$3,474,914.28	$5,645,622.18
Municipal engineering	632,262.18	434,888.34	1,067,150.52
Building construction	1,861,293.03	1,224,844.98	3,086,138.01
Total	4,664,263.11	5,134,647.60	9,798,910.71

The total expenditures on the plant account for buildings, to June 30, 1908, have been $9,824,089.15, and the cost of municipal improvements to date are as follows:

Panama waterworks and sewers	$853,849.23
Colon waterworks and sewers	601,043.91
Zone waterworks and sewers	2,358,840.44
Paving, Panama	489,007.77
Paving, Colon	293,231.26
Zone roadways	1,174,778.26
Total	5,770,750.87

Division of Motive Power and Machinery.

This division commenced the year with fairly complete shop organizations at Gorgona, Empire, and Paraiso, each in charge of a master mechanic, and during the year improvements in facilities and organizations were continued, so that at the present time any work which may develop can be quickly and economically handled.

GORGONA SHOPS.

The Gorgona shops, covering an area of 21 acres and having a trackage of 6 miles, have been equipped with particular view to making general repairs to locomotives, unloaders, bank spreaders, and wooden car equipment, in addition to such foundry and manufacturing work as conditions necessitate. With the completion of work authorized and under construction these shops will embrace the following:

Locomotive department (floor area, 179,993 square feet):
- Machine shop, 110 by 180 feet and extension 30 by 90 feet.
- General foreman's office and tool room, 32 by 76 feet.
- Erecting shop and platform, 120 by 475 feet (covering 22 pits).
- Transfer table pit, 50 by 475 feet.
- Boiler shop, 90 by 288 feet and extension 90 by 100 feet.
- Blacksmith shop, 60 by 180 feet.
- Power house, 40 by 104 feet.
- Bar iron rack, 20 by 115 feet.
- Paint shop, 60 by 120 feet.
- Office building, 66 by 66 feet.
- Instrument repair shop, 30 by 40 feet.
- Engine house, 50 by 150 feet (containing 2 tracks, washout pits running full length of house, double cinder pits 50 feet long, with necessary water cranes, coal-crane track, and coal storage for hostling and running repairs to engines).
- Sand house, 10 by 40 feet.
- Engine-house office, 15 by 15 feet.
- Lye-vat shed for cleaning engine parts, 25 by 50 feet.
- 200-ton blacksmith coal bin.

Car and foundry department (floor area, 127,012 square feet):
- Car shop, 50 by 325 feet (has two lean-tos 30 by 325 feet and 44 by 87 feet. Building covers car shop, machine shop, pattern shop, carpenter shop, office, and blacksmith shop for light work).
- Planing mill, 60 by 150 feet.
- Foundry, 70 by 161 feet (enlarged during year).
- Sand house, 25 by 50 feet.
- Coke shed, 25 by 130 feet.
- Lavatory, 22 by 112 feet.
- Latrine, 25 by 62 feet.
- Pattern storage, 40 by 60 feet.
- Car shed, 110 by 600 feet (covers 48 cars at one time).

Practically one-third of the output of this shop has been manufactured material, most of which could not have been purchased in the United States without delay to the work; the balance was special material which it was necessary to construct to order. The general manufacturing work is diverse and complicated, consisting of a large amount of emergency work and a large variety of jobs, so that there are all the conditions of the job shop together with the ordinary factory process. In the foundry, during this year, 4,279,237 pounds of gray iron castings were made, including 50,000 pounds of semi-steel castings and 216,947 pounds of brass and bronze castings. Systematic effort toward the reduction in cost of castings has resulted in

producing gray iron castings at an average cost of $0.0359 per pound, as against $0.0391 per pound, the cost last year. The cost of brass castings is $0.1951. One thousand four hundred and sixty-two patterns for castings were made during the year, cost of which is included in the cost of castings.

Included in the operation of the Gorgona shops, at Tabernilla there is an engine house 100 by 34 feet and office 10 feet 4 inches by 15 feet 4 inches, for the handling of small repairs to equipment which ties up at that point over night in connection with the operation of the Tabernilla dumps.

The new 1,200-horsepower boiler plant, at the Gorgona shops, has been completed, and is equipped to burn fuel oil.

EMPIRE SHOPS.

The Empire shops, located about midway in the Culebra division, have been specially designed and fitted up for doing general repairs to steam shovels, steel car equipment, rock drills, and similar excavating machinery. With the completion of extensions and new work authorized and in course of construction, the Empire shops will consist of the following:

Locomotive department (floor area, 136,354 square feet):
- Machine shop, 80 by 224 feet.
- Boiler shop, 150 by 224 feet.
- Blacksmith shop, 80 by 224 feet.
- Erecting shop, 80 by 362.5 feet (covering 14 pits).
- Paint shop, 20 by 30 feet.
- Oil house, 16 by 16 feet.
- Sand house, 10 by 20 feet.
- Cleaning shed, 16 by 32 feet.
- S. S. shipper shaft shop, 14 by 32 feet.
- Air compressor plant, 31 feet 4 inches by 90 feet 8 inches.
- Foreman's office, 12 by 12 feet.
- Power plant, 42 by 141 feet.
- Electric plant, 35 by 86 feet 2 inches.
- Boiler house, 31 feet 4 inches by 72 feet.
- Transfer table pit, 60 by 362 feet.

Car department (floor area, 61,875 square feet):
- Car shop, 100 by 405 feet (5 tracks).
- Planing mill, 75 by 225 feet.
- Office, 30 by 50 feet.
- Lavatory, 32 by 50 feet.
- Latrine, 20 by 70 feet.

Practically the entire shop plant at Empire was finished and equipped during the fiscal year covered by this report. The erection of new buildings and the installation of new and transfer of old machinery considerably handicapped the shop operation. The new facilities have been arranged to secure the quickest, best, and most economical handling of work and material.

The operation and maintenance of the air-compressor plants located at Empire, Las Cascadas, and Rio Grande falls under the Empire shop management. During the year these plants compressed, on an average, 275,000,000 cubic feet of air per month; cost of same, per thousand cubic feet, ranging from $0.053 in December, 1907, to $0.0344 in June, 1908.

The following are also included in the operation of the Empire shops, and comprise a floor area of 62,560 square feet:

Rio Grande:
- Engine house, 54 by 180 feet (the completion of this engine house made possible the abandonment of the Cucuracha engine house, an old French structure, which was unsatisfactory).
- Office and storeroom, 11 feet 6 inches by 15 feet 6 inches.
- Oil house, 16 by 16 feet.
- Sand house, 10 by 20 feet.
- Latrine, 12 by 20 feet.
- Air-compressor plant, 44 by 79 feet.
- Office, 14 by 19 feet.
- Store, 10 by 24 feet.
- Boiler house (old), 32 by 79 feet.
- Boiler house (new), 41 by 89 feet.

Lirio: Engine house, 26 by 121 feet.

Las Cascadas:
- Engine house, 90 by 300 feet.
- Shop, 20 by 64 feet.
- Store, 23 feet 6 inches by 40 feet.
- Air-compressor plant, 35 feet 6 inches by 86 feet.
- Boiler house, 46 by 86 feet.
- Office, 12 by 16 feet.
- Car shed, 20 by 60 feet.
- Coal chute (twenty pockets).

PARAISO SHOP.

The Paraiso shop is located on the east side of the south end of the "Culebra cut," and handles light repairs to all classes of equipment on that side and end of the "cut," as well as at the Pacific end of the canal, the heavy repair work being done at the Gorgona and Empire shops. The work of this shop includes locomotive and car work at Pedro Miguel and the operation of the Pedro Miguel coal chute.

During the year the erection of an entirely new set of shop buildings was completed at Paraiso, and all the machinery from the old shops, as well as a large amount of new machinery, has been installed, and the shops equipped with water and steam and air lines. It consists of the following:

Paraiso (floor area, 41,000 square feet):
- Machine shop, 60 by 160 feet.
- Blacksmith and boiler shop, 85 by 160 feet.
- Office, 20 by 50 feet.
- Erecting shop, 73 by 150 feet.
- Latrine and lavatory, 32 by 60 feet.
- Iron rack, 20 by 60 feet.
- Carpenter shop, 32 by 60 feet.
- Rope walk, 15 by 60 feet.

Pedro Miguel (floor area, 41,382 square feet):
- Engine house, 72 by 348 feet.
- Car-repair shed, 20 by 78 feet.
- Machine shop, 26 by 60 feet.
- Oil house, 16 by 16 feet.
- Coal chute, 36 by 125 feet (20 pockets).
- Car-repair shed (new), 32 feet 5 inches by 260 feet.

FORCE EMPLOYED.

On June 30, 1908, the organization of the division of motive power and machinery consisted of 2,206 employees, divided as follows:

Superintendent of motive power and machinery (including clerical forces of all shops)	143
Gorgona shops	882
Empire shops	811
Paraiso shop	265
Electrical subdivision	105
Total force, June 30, 1908	2,206

During the year 609 artisans and clerks were sent down from the United States for this division, of which number 333, or 55 per cent, are still in the employ of the commission, as against 36 per cent retained from the number sent down the previous year. This shows the greater stability of force as at present constituted, owing both to the higher class of personnel and improved conditions of work on the Isthmus.

In the past, the general efficiency of skilled labor on the Isthmus has not compared favorably with the same class in the United States. Though there are many first-class mechanics and skilled specialists in the service, the effect of the continued hot weather, which is very enervating, reduces their energy and activity to a considerable degree after a few months. It is believed that the general efficiency of skilled labor on the Isthmus is from 15 per cent to 25 per cent less than it is in the United States, due to climate and other unavoidable causes. This percentage of lessened efficiency is even greater in the case of helpers and laborers employed by the commission, most of whom are drawn from the northern parts of Spain and from the West Indies. Their physical and mental makeup is not comparable with that of men employed to do the same class of work in the United States. In addition to which they are slow, lazy, and indifferent.

It has been demonstrated in a number of instances, to the satisfaction of those in charge of the shops, that for work requiring a fair amount of mechanical skill, the average "gold" mechanic at 65 cents and up per hour, is a cheaper and more satisfactory man than "silver" employees, whose rates of pay run from 32 cents to $1 silver per hour, and average, perhaps, one-half or less that of the "gold" mechanics. It is only on the rougher and simpler classes of work that "silver" labor can be employed to advantage. On car-repair work it has been found impossible to handle heavy repairs on 40-ton wooden flat cars with "silver" labor. After filling the shop with "bad-order" cars it would take several days for "silver" mechanics to make the necessary repairs, whereas since "gold" mechanics have been detailed on this work, with "silver" employees as laborers and helpers only, it has been found possible to repair cars to the full capacity of the car shop tracks on an average of three times in two days. On the other hand, the white helper, at 38 or 44 cents an hour, on certain classes of strictly helper's work, particularly in the machine and boiler shops, has proved a distinct failure, as the average "gold" mechanic helper, after a very short period, becomes dissatisfied and indifferent and practically demands a mechanic's rating, and if same is not granted takes his discharge. In other words he seems to consider that he is above doing work which, in the United States, is classed as legitimate helper's work and seems to feel that same should

be performed by the "silver" labor. As a result, it has been found necessary to eliminate this class of help entirely, except in running drill presses, punches, shears, and similar machinery.

In December, 1907, a considerable reduction in this division was made, in order to get the force on a more economical basis, and on account of the completion of a large amount of work on hand. This resulted in a net decrease in force of 557 employees, with a consequent reduction in pay roll of $30,044.56 per month. Since this reduction was effected there has been some increase in the forces of this division to man the new shops completed at Empire during the closing months of the fiscal year, and to carry on the increase of work.

Statement of principal items of equipment in service or available on the Isthmus on July 1, 1907, and June 30, 1908.

Item.	Average cost each, delivered at Colon.	In service. July 1, 1907.	In service. June 30, 1908.
Steam shovels:			
1¼-yard dipper	$6,787.50	0	[illegible]
1¾-yard dipper	7,100.00	3	10
2½-yard dipper	9,391.00	25	42
5-yard dipper	12,780.00	32	48
Locomotives:			
French	4,250.00	99	126
New American	11,600.00	160	164
Cars:			
French dump	225.00	240	559
American dump	1,400.00	465	1,122
Wooden flat	1,150.00	1,601	1,798
Steel flat	951.00	500	609
Narrow-gauge	227.00	9	25
Cranes, American	9,300.00	11	20
Lidgerwood unloaders	5,400.00	18	30
Track shifters (manufactured on Isthmus)	4,050.00	3	9
Pile drivers (18 manufactured on Isthmus)	3,700.00	6	18
Bank or earth spreaders	5,200.00	18	23
Unloading plows	950.00	32	46

All of the above equipment was erected and made ready for service by or under the supervision of the mechanical division, the cost of which is not included in the unit costs above.

The following is a statement of some of the principal items of repairs accomplished during the year:

Item.	Gorgona.	Empire.	Paraiso.	Cristobal shops, Panama R. R. Co.	Electrical subdivision.
Locomotives:					
Repaired in shops	59	70	99		
Running repairs	3,232	12,144	6,634		
Erected, new				4	
Cars:					
Erected new				1,003	
Repaired	23,125	47,177	21,082		
Work equipment:					
Erected	10			10	
Repaired	2,247	272	1,379		
Steam shovels:					
Repaired in shops		41	14		
Running repairs to December 1, 1907[a]		459	394		
Erected		37		1	
Locomotives cared for nights	8,318	29,922	21,122		
Dynamos installed					1
Fire-alarm systems installed					1
Electric lights installed					23,365
Castings manufactured:					
Iron .... pounds	4,294,553				
Brass .... do	217,134				
Patterns for castings	1,462				

[a] Running repairs to steam shovels turned over to division engineers December 1, 1907.

The cost of repairs made by the mechanical division during the year on the different units of equipment enumerated in the above table, including all direct labor and material charges, was as follows:

Unit.	Number in service.	Number of repairs.	Cost per unit per annum.	Cost per unit per repair.
Locomotives	300	22,109	$1,005.95	$13.65
Freight cars	4,075	91,632	113 49	5.09
Work cars	90	862	374.17	39.07
Steam shovels (shop repairs only)	101	55	1,440.39	2,645.08

Excavation by steam shovels during the year was 17,467,161 cubic yards. Cost of shop repairs to steam shovels per cubic yard was $0.0083.

In addition to the above work 10.3 miles of pole line were constructed during the year, for use in conjunction with electric-lighting plants, making a total pole line mileage at the close of the year of 25 miles.

During the year 67 tests were made by the testing engineer of this division. His work included also the installation of oil-burning apparatus at various points. At the end of the year 3 stationary power and pumping plants in this division had been equipped for the use of fuel oil.

Three thousand five hundred and eighty boiler inspections and tests were made during the year by the boiler-inspection service, under the division of motive power and machinery.

Statement of expenditures made by the mechanical division for the year.

	Labor.	Material.	Total.
Maintenance and repairs	$1,303,151.82	$648,466.97	$1,951,618.79
New equipment	237,388.77	2,353,148.17	2,590,536.94
Other departments	630,167.81	473,299.14	1,103,466.45
Total	2,170,707.90	3,474,914.28	5,645,622.18

The work of this division has been handicapped somewhat by the peculiar conditions under which work is performed. Many features on the Isthmus, such as weather conditions, lower efficiency of labor, and the fluctuation in volume of work contribute to increased cost. During the rainy season, frequent showers interfere with the return of men to work in the afternoon and delay the handling of material between shops as well as the work of outside crews. Continued moisture in the air also makes necessary special care of tools and machinery. Absence from duty on account of vacation, sickness, injury, fire drill, band practice, and court attendance, etc., interferes with regularity in attendance of employees. These things, combined with the necessity of performing large emergency work promptly, entail the carrying of a larger force than would ordinarily be required were the work close to a market where repair parts and other necessities could be secured on short notice. Notwithstanding, it is believed that the cost of work compares very favorably with the cost of similar products purchased in the States and brought to the Isthmus. During the year 6,204 manufacturing orders were completed at an average

cost of $65.72 each. Statement of work covered by these manufacturing orders is omitted because of its length.

ELECTRICAL SUBDIVISION.

At the beginning of the fiscal year, electric light was being furnished to commission settlements at Culebra, Empire, and Gorgona from plants located at Empire and Gorgona, the former having a capacity of 4,000 16-candlepower lights and the latter 2,000 16-candlepower lights. The lesser cost and convenience of electricity for lighting purposes, as compared with the use of oil in lamps, as well as the additional fire protection which it affords, led the commission to extend this service to all commission settlements, except those between Gatun and Gorgona, which territory will be flooded upon the completion of the Gatun dam. This will be accomplished upon the completion of work authorized and now under way. During the year, the Empire power plant was increased from 200 to 400 kilowatt and arrangements made for the installation of an additional 400-kilowatt unit at this point.

On June 30, 1908, 17,186 16-candlepower lights had been installed and were in use in commission buildings, 13,365 of which were placed during the year. In addition 787 lights had been installed at Gatun, though not yet operated.

There have also been installed during the year by this subdivision three automatic fire-alarm telegraph systems at Ancon, Culebra, Empire, and Gorgona.

The work of this subdivision has also included the installation of electric motors and electrically driven cranes in the Empire shops, tests of mining caps and batteries, estimates for different kinds of electrically operated machinery, installation of lighting sets on dredges and other floating equipment, and other miscellaneous work of a similar nature.

DIVISION OF MUNICIPAL ENGINEERING.

The work performed by this division during the fiscal year may be divided into two classes: First, work done in the cities of Panama and Colon to improve sanitary conditions, cost of which is repaid to the United States through the collection of water taxes in those cities, in accordance with Article VII of the treaty between the United States and the Republic of Panama; and, second, work done in the Canal Zone and paid for from appropriations for the commission, or from revenues of the Canal Zone government. Included in the former is the laying of pavements and the construction of waterworks and sewerage systems, and, in the latter, paving, road making, grading, construction of waterworks and sewerage systems, and miscellaneous work of the same character.

Work in Panama and Colon during the year has not been very extensive and has consisted merely of small additions necessary to complete improvements previously authorized. Following is a statement of such work done during the year and the total amount of same to the end of the fiscal year.

	Panama.		Colon.	
	Placed during year.	Total June 30, 1908.	Placed during year.	Total June 30, 1908.
Waterworks:				
4-inch pipe ... feet..	323	9,127	5,554	6,924
Less than 4-inch pipe ... do...	....	....	4,882	17,574
6-inch pipe ... do...	....	40,552	1,066	17,968
8-inch pipe ... do...	550	6,608	....	5,936
10-inch pipe ... do...	....	1,444	....	4,309
12-inch pipe ... do...	....	1,448	....	742
16-inch pipe ... do...	....	1,235	....	....
20-inch pipe ... do...	....	60	....	15,827
Total ... do...	873	60,469	11,502	'69,280
House connections	....	2,093	264	1,147
Water meters tested and set	42	1,090	54	181
Hydrants	....	133	5	75
Water cranes	....	7	....	2
Hose valves	....	35	....	27
Venturi meters	....	1	....	1
Sewers:				
6-inch pipe ... feet..	....	2,200	4,102	20,183
8-inch pipe ... do..	....	36,004	140	3,134
10-inch pipe ... do...	....	....	207	2,334
12-inch pipe ... do...	....	16,263	315	'2,966
15-inch pipe ... do...	....	5,490	206	8,006
18-inch pipe ... do...	....	5,165	12	12
20-inch pipe ... do...	....	....	60	76
36-inch pipe ... do...	....	1,119	....	....
Various sizes ... do...	....	1,684	....	1,235
Total ... do...	....	67,925	5,042	37,896
Manholes	....	261	3	77
Catch-basins	....	227	4	77
House connections	....	1,019	....	264
Paving:				
Concrete curb ... linear feet..	....	51,401	5,745	41,267
Brick pavement ... square yards..	1,288	66,365	....	6,410
Concrete pavement ... do...	....	19,116	....	....
Macadam pavement ... do...	826	3,572	23,018	62,621
Basket gutter ... linear feet..	....	....	270	1,923

The sump, in Colon, into which all sewage flows, was completed in certain minor details during the year, though finished sufficiently to be operated during the previous year. Considerable work was done during the year in the D street canal, which runs the entire length of D street, Colon, and carries a large portion of the surface drainage of this city to the sea. One entrance to the canal is at Folks River and the other on the bay, below Colon Hospital, and the outflow of sewage is regulated by tidal gates located at both ends of the canal. During the year the depth of the canal was carried to about 2 feet below low tide, the canal cleaned its entire length, and sheet-piled between Fourth and Ninth streets.

The maintenance of sewers, waterworks, and pavements was transferred from this division to the superintendent of public works, department of civil administration, on September 1, 1907, in Panama, and on November 1, 1907, in Colon.

Four fires during the year, two in Panama and two in Colon, demonstrated the efficiency of the water service, the damage in all cases being confined to the immediate neighborhood of the buildings burned.

Municipal improvements in Panama and Colon, to June 30, 1908, cost $1,912,662.44, of which amount $1,018,387.27 were spent in Panama and $894,275.17 in Colon. Accessory to, but not a part of, the above improvements are the Rio Grande and Ancon reservoir and

pipe line, which cost, to December 31, 1907, $324,469.73. These works, being entirely within the Canal Zone, are to remain the exclusive property of the United States, and charge against the Panamanian Government for proper proportion of the cost of same will be made in the nature of a price per 1,000 gallons for water supplied the city of Panama. It is intended that the Brazos Brook reservoir and pipe line, cost of which is included in the cost of Colon improvements given above, shall be handled in a similar manner, and rental charged for all water supplied to the city of Colon.

A committee composed of representatives of the commission and Panama Railroad made an examination of the existing conditions and necessities, in Panama and Colon, in the way of further municipal improvements, consisting of the establishment of street-grade lines, and the extension of pavements, waterworks, and sewers in certain of the outlying sections which have sprung up since American occupation, the improvement of which was not contemplated in the original plans for this work in the two cities. In Colon, this district comprises a large area east of D street, some of which is at present occupied by shacks and tenements, and is most unsatisfactory and insanitary. In Panama, similar conditions exist in the Guachapali, Santa Cruz, and Cocoa Grove districts. The total estimated expenditures which will be required to place these districts in the same sanitary condition as other portions of Panama and Colon, which have already been thus improved, would approximate $1,000,000. The insanitary conditions which exist at the present time are fully appreciated, but unless there be introduced on the Isthmus some such disease as yellow fever or the plague, these conditions can not be said to be dangerous to the work of constructing the canal, and the expense is one which should be borne directly by the government of Panama. Under these conditions and in the absence of any specific appropriation by Congress sanctioning this work, it has been decided to do nothing in this connection, at least for the present.

CANAL ZONE.

Work of the second class performed by this division in the Canal Zone will be treated under the following headings: Waterworks, sewers, roads, and miscellaneous work. During the past year about 48 miles of water pipe and 14 miles of sewer pipe have been laid, making the totals to date approximately 88 miles and 41 miles, respectively. Twenty-two miles of macadam roads were constructed, making the total to date 32.5 miles.

WATERWORKS.

Four reservoirs and two pumping stations furnish water to the various settlements along the line of work, as well as the cities of Panama and Colon. The reservoirs are located at Rio Grande, Camacho, Gorgona, and Brazos Brook; the pumping stations at Tabernilla and Gatun. In addition to the above, there are 12 pumping stations on the Zone, which are used in conjunction with the water service, 9 of which are continually in service and 3 held in reserve for emergency use.

Rio Grande Reservoir.—During the year the elevation of the Rio Grande dam and spillway was raised and the storage capacity of the reservoir increased by 134,870,000 gallons. This reservoir now has a capacity of 496,670,000 gallons, at elevation 238; a drainage area of 2,015 acres, and a lake area of about 65 acres at the height of the spillway. This reservoir supplies all points south of Culebra, including Panama, Ancon, and La Boca, being connected with same by a 16-inch cast-iron main. The total consumption from this reservoir during the year amounted to 942,200,000 gallons, or an average daily consumption of 2,574,000. Of the above consumption, the city of Panama used about three-tenths, or 290,500,000 gallons, which, with a population of 36,388, made the daily consumption per capita 21.87 gallons. At its lowest elevation, 224, which was reached on May 1, 1908, the Rio Grande Reservoir had in store 228,423,000 gallons, as against 114,190,000 gallons, the contents of the reservoir at its lowest elevation in 1907, before the dam and spillway had been raised. All water used in Panama and Ancon is filtered before being passed into the mains by a filtration plant at Ancon, erected and put into operation during the year. This filtration plant is of the pressure type and has a capacity of 1,500,000 gallons daily.

During the year a survey was made of the valley drained by the Pedro Miguel River to ascertain the available supply which would be at hand and necessary during the construction of the masonry work on the locks at Pedro Miguel and Miraflores. The lowest weir measurement during the dry season showed a flow of 674,000 gallons per day, which, impounded by a small storage reservoir and the installation of pumping apparatus, will be ample to take care of all needs.

Brazos Brook Reservoir.—This reservoir supplies the country from Mount Hope to and including Colon and Cristobal. It is located about a mile and a half back of Mount Hope, on Brazos Brook. It has a drainage area of 640 acres and a lake area at spillway height of 120 acres. At its highest elevation, 48.5, it has a capacity of nearly 641,000,000 gallons. The consumption from this reservoir during the year was 457,544,000 gallons. During the year the necessity for an increased water supply at this point became apparent and the elevation of the dam and spillway was raised, the former from 50 to 53 and the latter from 45.1 to 48.5. This work involved the handling of 14,315 cubic yards of material and was performed at a cost of 30 cents per cubic yard. The capacity of the reservoir was increased by 215,460,734 gallons. It is believed that with this increased capacity there will be sufficient water supply to take care of demands of this vicinity for the near future. It will also render unnecessary the operation of a small pumping station at Mindi, which has been used in the past in connection with this water supply in emergencies, when the supply was in danger of being exhausted.

In connection with the Brazos Brook Reservoir there was installed during the year a 1,500,000-gallon pressure filtration plant, at a cost of $15,000, similar to the plant installed at Ancon. The results obtained from the operation of this filtration plant were not satisfactory on account of the large amount of vegetable matter carried in suspension, and it was decided to build and operate in conjunction with it a sedimentation basin with a capacity of 300,000 gallons. This basin is nearly completed and will soon be placed in operation. The

installation of two alum tanks and the placing of gates in the basin yet remains to be done. The basin consists of a reenforced concrete reservoir, built as a polygon with 20 sides, with a radius of about 51 feet and a depth of 8½ feet. It is divided by a partition wall in the middle and each side is subdivided into four separate basins. Water will enter into a gate chamber, where alum coagulant will be mixed with it; thence it will traverse, in diagonal courses, through the 8 basins, having an up-and-down motion from weir to weir; from the basins to the pumps and through the filtration plant proper, from which it will go to the standpipe. At the present rate of consumption, the water will take about four hours to travel from the intake to the pumps, which, it is believed, will satisfactorily clear the water prior to its entering the filtration plant.

Camacho Reservoir.—The construction of this reservoir was completed during the early part of the year. It is located at Camacho, back of Empire, and supplies the territory between Culebra and Bas Obispo, inclusive. It has a drainage area of 592 acres and a lake area of 38 acres at the height of the spillway. The capacity of the reservoir is 295,867,000 gallons. The annual consumption from this reservoir is 131,765,000 gallons, or a daily average consumption of 361,000 gallons. At the lowest elevation reached during the year there remained stored in the reservoir sufficient water for seventy-five days' use, at the present daily rate of consumption.

Carabali Reservoir.—This reservoir is located near Gorgona and furnishes water for the territory between Matachin and Mamei, though at the close of the dry season this supply is augmented by a pumping station near the Gorgona shops, which supplies water for locomotives from the Chagres River. The Carabali Reservoir has a capacity of 80,000,000 gallons, a drainage area of 1,552 acres, and a lake area at the height of the spillway of 20.5 acres. There is considerable inflow to this reservoir during the greater part of the year which, in past years, has been practically equal to the consumption; during the fiscal year covered by this report, however, the consumption has increased to such an extent as has made necessary consideration of means for securing additional water storage. Surveys were made and it was found practicable to locate a supplemental reservoir a short distance above the present reservoir. If its construction is decided upon, it will be at elevation 110, have a capacity of 153,000,000 gallons, and cost approximately $36,000. This work had not been authorized at the close of the year.

Tabernilla pumping station.—This pumping station supplies water to the territory from San Pablo to Frijoles. It is located about 1 mile back of Tabernilla, on the Frijoles River, from which water is pumped, and was placed in service during the past year. The station is equipped with three 12 by 8½ by 10 inch pumps and one 7 by 4½ by 9 inch pump, two of which are in operation all the time and two held in reserve. There is also in operation at this station a condensing plant, which furnishes distilled water to Tabernilla. During the year this plant has furnished an average of 1,000 gallons of distilled water per day for hotel and family use, pumped against a head of 70 pounds, and 500,000 gallons of water daily, pumped against a head of 120 pounds.

Gatun pumping station.—This station is located about a mile above Gatun, on the Gatuncillo River, and furnishes the water supply for

Gatun and vicinity. There are 3 pumps at this station, 2 of which are in constant use, the third being held in reserve. The distilling plant, located at Gatun during the early part of the year, was moved to the pumping station on the Gatuncillo River in the latter part of the fiscal year, for economic reasons. This distilling plant condenses about 1,200 gallons of water daily.

Because of the closing of the canal at Gatun, an emergency station was located on a hill about 20 feet above the level of the present station. This plant is of a temporary nature only and plans for a permanent station are being prepared at the present time.

The following pumping stations are used in connection with the Canal Zone water systems, principally for pumping water to the higher sections:

Ancon pumping station.—This station, consisting of two 10 by 8½ by 12 inch duplex pumps, supplies filtered water to the higher levels at Ancon. At this station during the year 200,000 gallons of water were pumped daily to the 50,000-gallon storage tank on Ancon Hill. In connection with this station a central boiler plant is operated, which furnishes steam to the Tivoli Hotel, Ancon Laboratory and Hospital, and for the purpose of pumping water to Ancon Laundry. At the present time the pumping station, which is located farther up on Ancon Hill, is being moved to the boiler house and there are being installed three 10 by 6 by 10 inch duplex pumps.

Paraiso pumping station.—There is one pump at this station, which pumps 95,000 gallons of water daily to the higher levels of Paraiso.

Cucuracha pumping station.—The location of this station was changed during the year to a point opposite its old location on Cucuracha Hill below Rio Grande, so as to secure a higher elevation and enable the use of the pumps at all stages of water in the Rio Grande Reservoir. The new station contains two 14 by 10 by 16 inch single-acting pumps, which were a part of the old French stock and have given good satisfaction. One pump at the old station is still in service and will be used until the new station is in operation. The daily amount of water pumped is 350,000 gallons. This station pumps water to three tanks on Contractors Hill, which supply water pumped at the Mount Zion pumping station.

Mount Zion pumping station.—This station consists of two 10 by 8½ by 12 inch duplex pumps, only one of which is in constant use, and pumps water for the higher levels at Culebra. It also pumps distilled water, condensed by a distilling plant at this station, to Rio Grande and Culebra. Two hundred thousand gallons of reservoir water were pumped daily during the year and 1,100 gallons condensed daily at this station. This station acts as a relay from the Cucuracha pumping station to the Mount Zion Reservoir, which has a capacity of 552,000 gallons. Arrangements are under way to supply this station with water from Camacho Reservoir, rather than from the Rio Grande Reservoir, as heretofore, as this will enable the Cucuracha station to be taken out of service for at least four-fifths of the year.

Camacho pumping station.—This station contains two 10 by 8½ by 10 inch duplex pumps, which supply water to the higher levels of Empire, and one 6 by 4 by 6 inch duplex pump, which supplies condensed water to houses, hotels, etc., at Empire. The former pump

100,000 gallons of water daily and the latter 1,500 gallons of distilled water.

Bas Obispo pumping station.—This station consists of two 10 by 8½ by 12 inch duplex pumps, with a capacity of 300,000 gallons per day. It is not now operated as the extension of mains from Las Cascadas to Bas Obispo supplies this town with water from the Camacho Reservoir.

Gorgona pumping station.—This station consists of two 10 by 8½ by 10 inch duplex pumps, one 12 by 8½ by 10 duplex pump, and one 7½ by 4½ by 7 duplex pump. It pumps water from the Carabali Reservoir to a small reservoir, in Gorgona, at elevation 264, the reservoir having a capacity of 279,000 gallons. Eight hundred and fifty thousand gallons of water are pumped daily against a head of 85 pounds. This station also pumps 2,700 gallons of distilled water daily to the hotels and machine shops at Gorgona and the town of Matachin.

Chagres pumping station.—This station consists of one 14 by 8½ by 10 inch duplex pumps, and, as stated before, pumps water from the Charges River to the Gorgona shops to supply engines and boilers with water. Its capacity is 400,000 gallons per day. It is only used during periods of low water in the Carabali Reservoir.

Mount Hope pumping station.—This is the largest pumping station on the Isthmus and furnishes water for Cristobal and Colon. During the year 1,200,000 gallons of water were pumped daily at this station, which consists of two 14 by 20 by 17 by 15 duplex pumps. The average pressure of 40 pounds was increased to 70 pounds in case of fire. The auxiliary station at Mindi, which is used at low-water periods of Brazos Brook Reservoir, consists of one 10 by 8½ by 12 inch duplex pump and one 14 by 10 by 16 inch single-acting pump. From June 11, 1907, to May 1, 1908, while this station was in use, 400,000 gallons of water were pumped daily to the ship yard, railroad tanks, and a part of Cristobal.

All permanent pumping stations, with the exception of Mount Zion pumping plant, are using oil for fuel instead of coal. It is believed that this will result in a saving of 30 per cent of the cost of operating these stations.

During the year authority was secured for the construction of a million-gallon reserve-storage reservoir on Ancon Hill, near the present 50,000-gallon tank, for the purpose of affording additional fire protection to Ancon, Panama, and La Boca. This work will be begun shortly.

Great care has been taken to safeguard the purity of the different water supplies. Through the courtesy of the Department of Agriculture, Mr. J. O. Meadows, physiologist, Bureau of Plant Industry, was assigned to duty on the Isthmus in this connection. Careful study of the various water supplies has been made and such steps taken as were necessary to remedy local conditions affecting the quality of water furnished. His report on the waters of the Isthmus is appended hereto. (Page 111.)

The water inspection service was carried on effectively during the year to prevent wastage and leakage in water supplies. As practically three-fourths of the water supplies have to be pumped, using steam, and any wastage means an increased expenditure for

this purpose, the importance of this water-inspection service is evident. It is believed that this service has more than paid for itself during the year by savings effected by its work.

The following is a statement of additions made to the waterworks systems during the year and total work done to June 30, 1908, in the Canal Zone:

Canal Zone waterworks systems.

	Work done during year.	Total to June 30, 1908.
La Boca:		
8-inch pipe ....feet..	29	1,521
6-inch pipe ....do...	495	15,009
4-inch pipe ....do...	11,822	16,307
Smaller than 4-inch.do...	5,300	7,740
Total ....do...	17,646	40,577
House connections	80	80
Hydrants installed.......	6	16
Hose valves placed.......	6	64
Ancon:		
20-inch pipe ....feet..	....	2,000
16-inch pipe ....do...	....	4,370
8-inch pipe ....do...	4,124	6,026
6-inch pipe ....do...	2,029	12,794
4-inch pipe ....do...	1,126	8,743
Smaller than 4-inch.do...	804	7,369
Total ....do...	8,083	41,302
House connections	59	165
Hydrants installed.......	2	38
Hose valves	22	56
Venturi meters...........	3	3
Corozal:		
6-inch pipe ....feet..	....	945
4-inch pipe ....do...	12	1,512
Smaller than 4-inch.do...	3,505	5,986
Total ....do...	3,517	8,443
House connections........	8	37
Water meters..............	....	3
Hydrants..................	....	3
Hose valves	....	23
Miraflores:		
4-inch pipe ....feet..	57	57
Smaller than 4-inch.do...	3,604	4,570
Total ....do...	3,661	4,627
House connections........	24	27
Pedro Miguel:		
6-inch pipe ... .feet..	11	357
4-inch pipe ....do...	769	2,406
Smaller than 4-inch.do...	2,921	5,255
Total . ...do...	3,701	8,018
House connections	7	63
Water meters.............	7	7
Hydrants..................	1	1
Hose valves	8	22
Paraiso:		
6-inch pipe ....feet..	....	5,342
4-inch pipe ....do...	396	4,037
Smaller than 4-inch.do...	3,013	4,686
Total ....do...	3,409	14,065
House connections.......	39	100
Water meters.............	8	8
Hydrants..................	....	10
Hose valves	6	10
Venturi meters...........	1	1
Cucuracha:		
4-inch pipe ....feet..	....	800
Smaller than 4-inch.do...	....	2,860
Total ....do...	....	a3,660
Water meters.............	1	1
Culebra:		
20-inch pipe ....feet..	....	3,930
8-inch pipe ....do...	745	2,309
6-inch pipe ....do...	3,657	15,972
4-inch pipe ....do...	1,220	9,937
Smaller than 4-inch.do...	3,607	13,065
Total ....do...	9,229	45,213
House connections	34	228
Hydrants..................	6	20
Hose valves	24	47
Empire:		
20-inch pipe ....feet..	....	2,005
16-inch pipe........do...	....	4,937
12-inch pipe........do...	....	12,464
10-inch pipe........do...	....	5,664
8-inch pipe.........do....	....	4,090
6-inch pipe.........do....	5,452	[illegible]
4-inch pipe.........do....	4,501	9,133
Smallerthan4-inch.do....	5,339	8,117
Total.............do....	15,292	b57,302
House connections	54	189
Hydrants..................	15	[illegible]
Hose valves	24	46
Las Cascadas:		
8-inch pipe ....feet..	8,400	8,400
6-inch pipe.........do....	....	2,025
4-inch pipe.........do....	2,940	4,300
Smallerthan4-inch.do....	8,465	12,745
5-inch pipe.........do....	....	390
Total.............do....	19,805	27,860
House connections	29	247
Hydrants..................	1	2
Public taps	8	27
Hose valves	....	40
Tanks	....	6
Bas Obispo:		
8-inch pipe ....feet..	5,780	5,780
6-inch pipe.........do....	110	880
4-inch pipe.........do....	6,070	6,070
Smallerthan4-inch.do....	9,143	11,739
Total.............do....	21,103	24,469
House connections	25	207
Hydrants..................	2	2
Wat r cranes	....	1
Public taps	4	15
Hose valves	32	82
Tanks	....	12

a 2,946 feet removed during year.

b 965 feet 4 inches removed during year.

Canal Zone waterworks systems—Continued.

	Work done during year.	Total to June 30, 1908.
Matachin:		
Smaller than 4-inch pipe .... feet..	....	4,400
House connections	15	178
Hydrants	....	2
Water cranes	1	1
Public taps	2	16
Hose valves	....	6
Tanks	1	2
Gorgona:		
10-inch pipe .... feet..	590	a 590
8-inch pipe .... do....	1,625	3,640
6-inch pipe .... do....	1,500	12,945
4-inch pipe .... do....	2,000	15,765
5-inch pipe .... do....	955	955
Smaller than 4-inch .do....	33,142	a 37,832
Total .... do....	39,812	71,727
House connections	91	390
Hydrants	5	27
Water cranes	1	5
Public taps	15	15
Hose valves	30	48
Tanks	4	6
Mamei:		
House connections	9	9
Public taps	3	3
San Pablo:		
House connections	34	34
Public taps	8	8
Hose valves	16	16
Tabernilla:		
10-inch pipe .... feet..	920	920
8-inch pipe .... do....	1,075	1,075
5-inch pipe .... do....	5,255	6,580
4½-inch pipe .... do....	13,600	13,600
Smaller than 4 inches, feet	19,932	28,595
Total .... feet..	40,782	50,770
House connections	17	121
Water cranes	5	5
Tabernilla—Continued.		
Public taps	....	17
Hose valves	....	23
Tanks	4	5
Gatun:		
8-inch pipe .... feet..	3,620	3,620
6-inch pipe .... do....	11,265	17,015
5-inch pipe .... do....	11,265	14,840
4½-inch pipe .... do....	2,004	2,004
4-inch pipe .... do....	726	726
Smaller than 4 inches, feet	22,313	22,313
Total .... feet..	51,193	60,518
House connections	44	181
Hydrants	3	3
Water cranes	1	1
Public taps	11	11
Hose valves	....	27
Tanks	3	4
Standpipes	....	2
Mount Hope:		
Water meters	1	2
Public taps	5	5
Hose valves	....	24
Tanks	....	4
Venturi meters	....	1
Cristobal:		
10-inch pipe .... feet..	....	2,957
8-inch pipe .... do....	....	1,635
6-inch pipe .... do....	2,253	19,158
4-inch pipe .... do....	3,396	3,396
Smaller than 4 inches, feet	10,196	10,196
Total .... feet..	15,845	37,342
House connections	64	64
Water meters	15	15
Hydrants	53	96
Hose valves	....	25
Tanks	....	2
Venturi meters	....	2

a Include Matachin.

Recapitulation.

Water pipe	253,078	462,951
House connections	583	2,320
Tanks	12	41
Standpipes (railroad)	....	2
Hydrants	94	245
Hose valves	168	504
Venturi meters	4	7
Water meters	32	36
Public taps	51	117
Water cranes	8	13

SEWERS.

Nearly 98 per cent of all quarters constructed by the commission have been connected with the Zone sewerage systems, as well as all office buildings and shops. Following is a statement of the amount of sewer pipe which has been laid in the Canal Zone.

Canal Zone sewerage systems.

	Work done during year.	Total to June 30, 1908.
La Boca:		
8-inch pipe ....feet..	1,347	2,051
6-inch pipe.........do....	3,859	6,805
4-inch pipe.........do....	....	1,552
Total.............do....	5,206	10,408
Manholes.................	16	31
House connections.......	16	62
Ancon:		
12-inch pipe ....feet..	....	39
8-inch pipe.........do....	2,323	8,266
6-inch pipe.........do....	2,637	14,202
4-inch pipe.........do....	100	1,235
Total.............do....	5,060	23,742
Manholes.................	19	81
House connections.......	60	152
Corozal:		
8-inch pipe ....feet..	....	1,672
6-inch pipe.........do....	1,080	4,377
4-inch pipe.........do....	....	791
Total.............do....	1,080	6,840
Manholes.................	1	26
House connections.......	....	25
Miraflores:		
10-inch pipe ....feet..	538	538
8-inch pipe.........do....	622	622
6-inch pipe.........do....	715	715
Total.............do....	1,875	1,875
Manholes.................	7	7
House connections.......	11	11
Pedro Miguel:		
10-inch pipe ....feet..	100	100
8-inch pipe.........do....	327	3,403
6-inch pipe.........do....	871	6,920
4-inch pipe.........do....	....	965
Total.............do....	1,298	11,388
Manholes.................	4	39
House connections.......	9	63
Paraiso:		
12-inch pipe ....feet..	....	396
8-inch pipe.........do....	284	4,500
6-inch pipe.........do....	3,266	8,233
4-inch pipe.........do....	....	420
Total.............do....	3,550	13,549
Manholes.................	10	46
House connections.......	21	79
Cucuracha:		
6-inch pipe ....feet..	2,003	2,003
Manholes.................	4	4
House connections.......	5	5
Culebra:		
8-inch pipe ....feet..	1,793	10,746
6-inch pipe.........do....	3,787	15,536
4-inch pipe.........do....	....	3,103
Various sizes.......do....	96	640
Total.............do....	5,676	30,025
House connections.......	89	218
Empire:		
12-inch pipe ....feet..	....	137
8-inch pipe.........do....	778	14,508
6-inch pipe.........do....	4,767	15,895
4-inch pipe.........do....	....	2,048
Total.............do....	5,545	32,588
House connections.......	42	177
Las Cascadas:		
36-inch pipe ....feet..	86	86
8-inch pipe.........do....	....	550
6-inch pipe.........do....	....	5,810
Total ....do....	86	[a] 6,446
House connections.......	29	247
Bas Obispo:		
6-inch pipe ....feet..	7,925	9,090
House connections.......	25	175
Matachin:		
8-inch pipe ....feet..	....	850
6-inch pipe.........do....	....	1,275
Various sizes.......do....	....	3,850
Total.............do....	....	5,975
House connections.......	15	51
Gorgona:		
12-inch pipe ....feet..	....	150
10-inch pipe.........do....	1,100	1,100
4-inch pipe. ....do....	350	350
Various sizes.......do....	17,185	25,090
Total.............do....	18,635	26,690
House connections.......	91	390
Tabernilla:		
8-inch pipe ....feet..	242	3,600
6-inch pipe.........do ...	4,483	8,780
Total.............do....	4,725	12,380
House connections.......	60	164
Gatun:		
10-inch pipe ....feet..	1,790	1,790
8-inch pipe.........do....	1,427	4,960
6-inch pipe.........do....	....	6,250
Total.............do....	3,217	13,000
House connections.......	44	238
Cristobal:		
20-inch pipe ....feet..	....	327
15-inch pipe........do....	396	1,744
10-inch pipe........do....	100	618
8-inch pipe.........do....	2,949	3,408
6-inch pipe.........do....	1,586	4,063
4-inch pipe.........do....	1,116	1,116
12-inch pipe.........do....	700	700
Total.............do....	6,847	11,976
Manholes.................	20	20
Catch basins........	....	12
House connections.......	64	106

[a] 1,951 feet 6 inches removed.

Recapitulation.

Water pipe ....feet..	72,678	217,975	Catch-basins..................	....	12
Manholes....................	81	254	House connections............	441	2,162

ROADS.

The construction of roads in the Canal Zone has progressed during the year as made necessary by the construction of new quarters and other buildings. The cost of roads is a very considerable item. because in order to withstand the traffic and weather conditions they have to be of the macadam type with an extra heavy macadam surface. The following is a statement of road work performed:

Location and item.	Work done during year.		Total to June 30, 1908.	
	Length.	Quantity.	Length.	Quantity.
	Feet.	*Sq. yds.*	*Feet.*	*Sq. yds.*
Ancon:				
Macadam	13,289	22,148	60,094	100,231
Paths	1,308	654	1,308	654
Corozal: Macadam	3,500	5,833	3,500	5,833
Pedro Miguel. Macadam	3,780	6,300	3,780	6,300
Paraiso: Macadam	2,939	4,898	2,939	4,898
Culebra:				
Macadam	11,590	19,316	21,570	35,949
Paths	2,200	1,100	6,525	3,262
Empire:				
Macadam	5,463	9,105	18,138	30,230
Paths	2,400	1,200	2,400	1,200
Las Cascadas: Macadam	552	920	3,682	6,136
Bas Obispo: Macadam	2,284	3,806	6,170	10,282
Gorgona: Macadam	7,360	11,155	14,960	23,821
Tabernilla: Paths	1,700	850	1,700	850
Gatun:				
Macadam	7,830	13,050	17,080	28,383
Paths	5,000	2,500	5,000	2,500
Cristobal:				
Macadam	8,553	17,107	20,285	40,570
Brick on concrete	32	80	438	1,000
Paths	1,200	800	1,200	800
Total:				
Macadam	116,307	213,538	172,148	292,633
Brick on concrete	32	80	438	1,000
Paths	13,808	7,104	18,133	9,266

MISCELLANEOUS.

During the year, at Culebra Island, the new quarantine station in Panama Bay, a system of waterworks and sewers was constructed, walks built, and a floating landing stage placed in position. The latter, which is necessary to afford a landing at all stages of the tide, was nearly completed at the close of the fiscal year. The waterworks and sewer systems consist of the following:

Item.	Waterworks.	Sewers.
6-inch pipe ... feet..	1,186	1,000
Smaller than 4-inch pipe ... do....	4,269	....
Total ... do....	5,455	1,000
House connections	9	7
Public taps	1	....
Hose valves	15	....
Tanks	4	....
Manholes	....	1

At Taboga Island there have been installed by this division 2,040 feet of water pipe (smaller than 4-inch) and connected with it 5 hose valves; also 2,194 feet of sewer pipe of various sizes.

At Porto Bello 1,628 feet of 8-inch sewer pipe were installed during the year and connected with it 5 manholes.

During the year the rock crusher at Rio Grande, operated by this division, crushed 57,329 cubic yards of rock, at an average cost of $2.31 per cubic yard. At the end of the year rock was being crushed for about $1.75 per cubic yard. It is believed that with the crusher operating continuously and with a sufficient number of cars to take care of the entire daily output, the cost of crushing rock at this point could be reduced to $1 per cubic yard. At slack periods during the year considerable stripping was done, and it is estimated that 700,000 cubic yards of stone are now available for crushing.

In addition to the above work this division is charged with the construction of municipal improvements in native settlements under the jurisdiction of the Canal Zone government. Following is a statement of cost of this class of work performed during the year:

Roads and trails, maintenance	$903.42
Roads, new construction	16,654.77
Waterworks and sewers	14,280.16
Miscellaneous works	4,379.00
Total	36,217.35

A great deal of work in the way of road and trail construction and maintenance has been performed by convict labor and natives working out their poll tax. This has proved a very economical and satisfactory way of handling some of the least difficult portions of the above classes of work.

Statement of force employed by the division of municipal engineering.

	June 30, 1907.	June 30, 1906.
Gold	160	105
Silver	1,829	910
Total	1,989	1,015

EXPENDITURES.

The following is a statement of the expenditures of this division during the fiscal year:

	Material.	Direct labor.	Indirect labor and supervision.	Total.
Main office, Panama	$1,215.97	$1,448.59	$38,601.66	$41,266.22
Panama:				
Waterworks and sewers	8,784.39	10,449.89	5,602.90	24,837.18
Paving	15,841.12	13,275.38	6,812.11	35,928.61
Colon:				
Waterworks and sewers	18,691.06	20,071.61	9,144.33	47,907.00
Paving	35,424.63	19,171.68	8,485.35	63,081.66
Zone:				
Waterworks and sewers	220,043.21	183,824.23	112,332.20	516,199.64
Roads	73,691.18	119,553.57	56,895.79	250,140.54
Rio Grande crusher	7,411.87	67,093.39	13,284.41	87,789.67
Total	381,103.43	484,888.34	251,158.75	1,067,150.52

During the year systems of cost keeping have been introduced in this division, and accurate record kept of the cost of various individual items of work and the important units in same. By comparing such costs of similar work in each of the four subdivisions more satisfactory results have been obtained than heretofore. Assistant engineers in charge of the subdivisions have been required to estimate on the cost of work previous to authorization and have been required to see that the cost of work is kept within estimates. This is rather difficult in the rainy season, especially in road and trail work, as the continuous rains are conducive to higher costs.

Division of Building Construction.

For the performance of its work this division is divided into six districts, with a superintendent in each district having charge of all carpentry work; superintendents of plumbing, painting, and masonry are responsible for all work of this kind performed throughout the division. All superintendents report to the master builder. Plans for all work done originate in the architect's office, which is under the direction of the master builder. The only change in the organization of this division during the year was the abolition of the position of assistant master builder.

The average force employed during the year was 2,366 men, the maximum force being 3,525, employed in July, 1907, and the minimum force being 1,536 men, employed in April, 1908.

During the year a considerable reduction in force was made owing to the diminution of the work of the division. The following statement shows the forces of this division at the beginning and close of the fiscal year:

	Gold.	Silver.	Total.
July 1, 1907	1,044	3,083	4,127
June 30, 1908	326	1,040	1,366
Decrease during the year	718	2,043	2,761

The average pay of skilled and unskilled labor per hour is, for "gold" men, $0.625, and for "silver" men, $0.169.

The total expenditures of this division during the year are as follows:

	Labor.	Material.	Total.
Superintending, clerical, drafting, etc.	$190,226.94		$190,226.94
Construction of new buildings	1,253,186.48	$928,726.91	2,181,913.39
Repairs to American buildings on account of deterioration	64,230.92	41,250.87	105,481.79
Improvements to American buildings	85,790.00	99,055.44	184,845.44
Repairs to French buildings on account of deterioration	155,032.62	83,219.85	238,252.47
Improvements to French buildings	112,826.07	72,591.91	185,417.98
Total	1,861,293.03	1,224,844.98	3,086,138.01

Of the new construction the largest amount expended was for the construction of "gold" quarters, which cost $982,771.86. During the year 491 new buildings were constructed; 1,147 American buildings repaired on account of deterioration, and additions or improvements

made to 423 buildings; 1,178 old French buildings have been repaired on account of deterioration, and additions and improvements made to 275. To date 1,462 buildings have been constructed, and on July 1, 1908, the total number, including French buildings, on hand was 3,313.

A large item in the construction of buildings on the Isthmus is screening, which cost during the year $122,672.79 and, since American occupation to June 30, 1908, $421,882.64. Some trouble has been experienced from deterioration of some of the brass screening wire, and a careful investigation is under way to ascertain the cause of same. Under present specifications, which require wire to be of bronze, it is believed that permanency of the screening will be attained.

All buildings constructed are in accordance with approved type plans. Twenty-four types of living quarters have been designed for the accommodation of "gold" employees. For "silver" employees buildings have been designed which are adapted to the different nationalities which occupy them. All buildings are constructed in accordance with sanitary regulations in force and are protected by wire screening. For the use of "silver" employees laundry tubs of durable construction have been built in the different camps, and drying rooms, in which clothes may be dried overnight, have been furnished at the Fox River Camp and at Gatun. In the better type houses, occupied by "gold" employees as family quarters, drying rooms are provided, and at the close of the year work was under way to provide bachelor quarters as well with drying rooms for the convenience and comfort of the occupants.

In the drafting room of this division 115 sets of plans, consisting of 345 sheets of drawings, were prepared during the year, as well as plans and specifications for contract building work. On July 1, 1907, the drafting force consisted of 12 men, and on June 30, 1908, of 7 men.

Among the more important items of construction performed by this division during the year are the following: 33 hospital buildings, 37 storehouses, 7 fire department buildings, 9 laborers' bath houses, 26 laborers' range closets, 6 fumigation houses, 5 corrals, 9 schoolhouses, 5 commissaries, 1 clubhouse, 4 post-offices, 9 office buildings, 2 lodge halls, 18 standard laborers' barracks, 5 band stands, 2 Gallego mess halls, 5 hotels, 4 jails, 8 powder and detonator houses, 4 markets, 35 shop buildings, 8 laborers' washhouses, 3 bridges, and 200 type quarters for "gold" employees.

The Ancon wood and machine shop was operated by this division during the year for the manufacture of millwork, trim, and similar work. Seventy men have been employed at this shop at a cost of $39,327.87.

The principal items of work turned out at the Lirio planing mill are as follows:

Sash	pieces	11,441
Doors	do	11,780
Blinds	do	5,174
Screens	do	139
Cabinetwork	do	1,077
Woodworked articles	do	29,193
Resawed lumber	feet B. M.	319,000
Molding and finished lumber	feet	3,370,547

This mill employed an average of 58 men, at an annual cost of $55,880.59. All millwork for buildings, such as screening strips, quarter round, portable lattice screens, etc., is done at this mill, instead of on the job, as was the case in previous years. This was one of the steps taken to lessen the cost of building work on the Isthmus.

At Culebra, a small sawmill, used for ripping heavy lumber, was discontinued and the work transferred to the Lirio mill.

At Gorgona the sawmill was operated a portion of the year and during the month of April sawed 40,000 linear feet of 1-inch material from heavy timber, at a cost of about one-tenth of a cent per linear foot.

To supply the requirements of the masonry subdivision at Ancon and vicinity, there was operated by this division at Ancon a stone crusher of French construction. The total output during the year was 2,002 cubic yards, costing 88 cents per cubic yard.

In the cement block plant, at Ancon, there were manufactured during the year 17,969 concrete blocks, of various sizes, at a cost of 12½ cents per cubic foot, or an average of 25 cents per block. These blocks were used in the construction of 8 vaults for post-offices and general offices, 3 fire walls, 8 powder and detonator houses, 1 driveway, and chimneys of various sizes. The powder houses were built entirely of concrete blocks on solid concrete foundations, with iron doors. Blocks are made from a mixture of one part cement, three parts sand, and three parts stone chips, giving a tensile strength, when three months old, of 342 pounds per square inch. Powder houses constructed of these blocks have been tested and found to be bullet-proof.

During the year special attention has been given to reducing the cost of work in this division. This has been done by modifying and cheapening the cost of all type structures, through the elimination of unnecessary features; by the adoption of more suitable and more satisfactory materials and cheaper methods of application, and by requiring higher efficiency in the performance of work, through comparison of detailed cost statistics on work done in the different districts.

Some of the more important items eliminated in construction work are: Omission of extra studding on sides of doors and windows; omission of cross braces on verandas, omission of interior latticework, ornamental moldings, and double ceiling; omission of tile floors, omission of all repainting, except to prevent deterioration.

In the way of securing more satisfactory material and cheaper methods of application is the following: Ordering of dressed material from the United States, and of material in sizes that do not require ripping in order to make them ready for use; use of concrete blocks for uptakes or chimneys, instead of galvanized-iron pipe, which deteriorates rapidly; reducing the thickness of concrete floors and walks and, in some cases, substituting double wooden floors with tar paper between for concrete floors; centralizing plumbing work, doing away with long runs of pipe; reversing alternate sheets of roofing iron, by which two inches in each sheet is gained; performing millwork for buildings at the Lirio mill; painting of tile and galvanized-iron roofs with coal-tar paint instead of oil paints.

For securing greater efficiency in the performance of work, complete systems of cost keeping have been established covering all

branches of the work of this division. In the main office work costs have been divided into separate units, such as carpentry work, masonry work, plumbing work, painting work, and indirect charges (which includes office force, supervision, sick leave, transit time, vacation leave, holiday pay, and general labor not directly applicable to any one piece of work). Comparison of cost of similar work in all districts has resulted in uniformity in cost of like work throughout, superintendents striving to outdo each other in performing work at the least cost. The class of labor obtained from the United States has not been, as a whole, of the best, and this has been reflected in the high cost of building work. During the year, however, the least efficient of the "gold" mechanics have been separated from the service and the efficiency of the labor retained has, through proper systems of supervision, been increased more than 50 per cent. The following statement shows the present cost per cubic foot of some of the principal type buildings erected by the commission:

	Per cu. ft.
Type 5, 8-room bachelor quarters	$0.095
Type 14, 4-family quarters	.112
Type 17, 1-family quarters	.127
Type 18, 24-room bachelor quarters	.075

In order to stimulate economic building work in this division during the past year, the commission has constructed several buildings by contract, the commission furnishing all material and the contractor all labor. This caused an appreciable reduction in costs, and costs by commission forces will be held at the lower figures hereafter, or resort will again be made to contract work. With few exceptions, contractors performing work for the commission employed colored labor exclusively. A contractor is not subject to such indirect charges as vacation, sick and injury leave, all of which enter into the cost of commission-built structures. The results desired were obtained, however, and have brought about greater efforts toward the reduction in cost of work.

During the year, the 4 time-keeping and pay-roll offices of this division, carrying 23 clerks, at a monthly cost of $2,950, were reduced to 2, 1 at Ancon and 1 at the main office, Culebra. At the former office 2 men were stationed and at the latter 8 men, the monthly pay roll being reduced to $1,400 for this class of work.

In all districts and subdivisions foremen are held responsible for securing the proper day's work from men under them, and in cases where the cost of work is higher than it should be, satisfactory causes for such increased cost must be given. In the masonry subdivision it was found advantageous to reduce the size of the gangs, as this kind of work requires constant supervision on the part of foremen. Under this system the cost of piers and footings has been reduced to from $2.50 to $3 per cubic yard. In larger work in the masonry line the cost is considerably less.

Systematic efforts toward the reduction in cost of painting has decreased the cost of painting more than half. For instance, type No. 14 houses in November, 1907, cost $402.65 for painting, for labor only, and in June, 1908, $179.56. The work includes the following: Interior and exterior, 290 squares, given two coats; roof, 42 squares, given one coat; creosoting foundations and underside of first floor, 45 squares, given one coat. The cost per square averaged 27 cents for

labor only. The total cost of painting work was reduced considerably by the decision to do repainting only for the sake of preservation of buildings and not for appearance; also by the substitution of Cunningham coal-tar paint for oxide of iron paints in painting tile and galvanized-iron roofs. This paint, which is a mixture of 8 gallons of coal tar, 1 gallon of kerosene oil, and 12 pounds of Portland cement, is very much cheaper and has superior lasting qualities to any paint previously used. It costs 9 cents per gallon, mixed ready for use, and has been applied to over 2,000 commission buildings, the amount used during the year being over 15,000 gallons. Since American occupation approximately $1,000,000 has been spent for material and labor required in painting buildings.

Woodwork of buildings is subject to injury in various degrees, in different localities, from small white ants. It was thought at first that creosoting the foundations would prevent the entrance of ants. As soon as the creosote dried out, however, it was discovered that the ants ascended the foundation posts through small mud tunnels they built, and ate away joists, studding, and other timbers not exposed to the light. The most satisfactory and cheapest protection against this trouble has been found in employing cheap labor to make an inspection once or twice a month and destroy the mud tunnels. The cost of this inspection is about $2,500 per annum, and it saves a large amount in repairs which would otherwise soon be necessary.

In August, 1907, the plumbing subdivision took over from the department of labor, quarters, and subsistence the installation and repair of stoves and ranges in commission buildings.

The average cost for material and labor, per fixture, for installing plumbing last year was $50. This year the cost has been reduced to $41. The total number of plumbing fixtures installed since American occupation amounts to over 12,000, and the total cost of plumbing in all commission buildings has been a little over $1,000,000.

A large number of French buildings were roofed with hard-glazed French tile, which led to the adoption on a number of American buildings first constructed of tile as a roof covering. Something over 1,500 squares of American tile have been ordered and a large portion used, but the results have not been so satisfactory as the French found with this material. The American tile is more porous and not so hard as the French tile. Samples of French tile immersed in water for twenty-four hours show an absorption of 9.55 per cent, while American tile showed correspondingly an absorption of 15.12 per cent. Water under pressure penetrates American tile and drips through. One of the greatest objections to the use of American tile, however, is the breakage in shipment, amounting on an average to over 25 per cent. All of the tile roofs have been made water-tight after some difficulty, by cementing the joints and painting with Cunningham coal-tar paint. No more tiling, however, will be used for roofing, as the galvanized corrugated iron which is in general use has been found to be the cheapest and most satisfactory roof covering and, when protected from corrosion by Cunningham coal-tar paint, is durable.

The labor employed by this division consists of "gold" mechanics, most of whom are American citizens, and "silver" helpers and laborers, with a few "silver" employees classed as mechanics. Numbered among the "silver" employees are Jamaicans and other

West Indians, Hindus, Gallegos, and Italians. During the early days of American occupation practically the only skilled labor obtainable was American mechanics who came down from the United States, many of whom were not overly skilled in their trades. Since then many of the Jamaicans, who have worked under American foremen and with American mechanics from two to four years, have become quite skillful and competent mechanics, and in the building trades the better class of these colored mechanics are now able to perform, on the rougher and more simple classes of building construction, 75 per cent as much work as the average "gold" mechanic, at from one-third to one-half the latter's wages. This comparison is for mechanics. As far as labor is concerned, Gallego and Italian laborers, at 20 cents gold per hour, are cheaper and more satisfactory than colored labor at 10 cents per hour gold. Hindu laborers, at 20 cents per hour gold, are intermediate in efficiency between the white European laborer and the colored West Indian laborer.

In painting especially are "silver" mechanics much cheaper than "gold" mechanics. "Gold" painters receive from 65 to 70 cents gold per hour, and on average housework paint 8 squares per day of eight hours. "Silver" labor, the average pay of which is 20 cents gold per hour, averages 6 squares per day. In painting corrugated-iron roofs "silver" mechanics cover from 14 to 16 squares in eight hours and accomplish this work much cheaper than white painters, as the latter will not work on the steep roofs without the use of ladders, whereas the "silver" mechanics climb over them in their bare feet without ladders.

White tinners will never be required in any number on the Isthmus, as they can not endure the heat when working on the metal roofs, but for shopwork white tinners from the United States are much cheaper and more satisfactory.

On all classes of plumbing work the "gold" mechanic has proved himself much more efficient and satisfactory than "silver" employees.

During the present year the division of building construction worked into place approximately 20,000,000 feet of lumber, board measure; over 120,000 sheets of galvanized corrugated iron were used; 167,000 square yards of screening placed, and 250 tons of nails used.

The following is a statement of work done by this division at each station:

Taboga Island:
- N-1942, addition to the sanitarium.

Culebra Island (new quarantine station):
- Detention building for cabin passengers.
- Detention building for steerage passengers.
- Quarters for attendants and women steerage passengers.
- Building for attendants' quarters and storeroom.
- Plague laboratory.
- Laundry.
- Isolation hospital, 41 feet 8 inches by 41 feet 8 inches.
- Isolation hospital, smaller dimensions.
- Type 10 quarters for resident physician.

La Boca and East La Boca.—Sixteen old French buildings remodeled and repaired for quarters, and the following new constructions completed:
- N-1275. Office building.
- N-1276. 2 type 18 dormitories.
- N-1277. 1 type 14 quarters.

N-1278. 2 type 19 quarters.
N-1279. 1 type 8a quarters.
N 1280. 1 mess hall.
N-1281. 1 commissary.
N 1282. 1 sand house.
N 1284. 1 dynamite storehouse.
N 1285. 1 type 8 (revised).
N 1287. 1 oil storehouse.
N 1288. 1 type 18 dormitory.
N 1291. 1 cable house.
N 1292. Hospital waiting shed.
N 1294. Paint storehouse.

Panama. Cement storehouse demolished and renovation of Santo Tomas Hospital completed.

Ancon. Twenty-three old French buildings repaired for occupancy as quarters, mess hall, and hospital, and following new buildings completed:

N 38. Prison ward.
N 44. 4 type 17 quarters.
N 58. 11 buildings at insane asylum.
N 61. 1 type 18 dormitory.
N-62. Addition to hospital wards 9 and 10.
N 63. Contagious-disease ward.
N 64. Post-mortem and disinfecting building.
N 66. 4 type 14 quarters.
N 67. 8 type 17 quarters.
N 68. 2 type 19 quarters.
N 69. 1 type 18 dormitory.
N-71. 3 type 8 quarters.
N 73. Residence for head of department of civil administration.
N 74. Fumigation house.
N 75. Residence for the chief sanitary officer.
N 76. 1 type 18 dormitory.
N 77. Dispensary.
N-78. 1 type 17 quarters.
N-79. Filter plant.
N 80. 3 type 14 quarters.
N 81. Fire department building.
N 82. 4-room schoolhouse.
N 83. 1 type No. 25 quarters.
N-84. Coal house.
N 86. Band stand.
N 87. Post-office.
N 88. 2 type 14 quarters.
N 89. Venturi meter shed.
N 90. 2 type 17 quarters.
N 91. Telephone exchange.
N 92. 2 type 14 quarters (by contract).
N 93. 1 type 14 quarters.
N 94. 1 type 18 quarters (by contract).
N 95. Laborers' washhouse.

The 11 buildings above mentioned erected at the insane asylum consist of an administration building; a central kitchen; a dining room; 2 ward buildings for men, having a capacity of 32 and 44 beds, respectively; 2 ward buildings for men, having a capacity of 20 beds each, with separate dining room, nurses' offices, nurses' toilets, clothes and linen rooms; one women's ward, with a capacity of 16 beds, separate dining room, nurses' office, clothes and linen room; two 14-cell buildings for men and two 10-cell buildings for women; and attendants' quarters.

The administration building at Santa Rosa, originally intended for the governor's residence, was completed for office purposes during the year. This building cost $150,784.82.

Corozal. New buildings were completed as follows:

N 458. Fire department building.
N 462. Laborers' range closet.
N 468. Fumigation house.
N 469. Yardmaster's office.
N 470. Corral.
N 472. Coal box.

N-473. Division engineer's office building.
N-474. 2 type 14 quarters.
N-475. 1 type 17 quarters.
N-477. Hotel help's quarters.
N-480. 1 type A jail.
N-481. 1 type 21 quarters.

Cocoli.—Several tents erected and screened.

Miraflores.—Three old French buildings were repaired for occupancy as quarters, jail, and sick camp, and the following new buildings completed:

N-1605. Standard laborers' kitchen.
N-1606. European mess hall and kitchen.
N-1607. Storehouse for sanitary department.
N-1609. Laborers' bath house.

Thirty old French buildings at this point had been repaired and equipped for occupancy previous to the fiscal year covered by this report. These buildings had been used by the sanitary department in the care of insane patients until the completion of the new asylum at Ancon. Upon the decision to locate two of the canal locks, at the Pacific end, at Miraflores, instead of at La Boca, these buildings were adapted to take care of the forces transferred to Miraflores.

Pedro Miguel.—Nine old French buildings repaired for occupancy as quarters and nine old French barracks at Pedro Miguel junction demolished; new work was completed as follows:

N-1826. 5 type 14 quarters.
N-1829. Fumigation house.
N-1830. Engine house.
N-1831. 1 type 18 dormitory.
N-1832. Shed.
N-1833. Powder and detonator house.
N-1834. Storehouse for division engineer.
N-1835. Commissary help's quarters.
N-1836. Machine shop.
N-1837. Hospital waiting shed.
N-1838. 3 type 14 quarters.
N-1840. Bath house.
N-1841. Market.
N-1842. Unloading platform for hotel.

Paraiso.—Fifteen old French buildings repaired for occupancy as quarters, storehouse, and office, and shop plant for mechanical division completed. Twelve old French buildings removed on account of slide on the eastern side of the canal, and the construction of a new camp to take the place of these old French buildings was started in June, 1908. New work was completed as follows:

N-1731. Erecting shed.
N-1732. Boiler and blacksmith shop.
N-1733. Carpenter shop.
N-1734. Machine shop.
N-1736. Storehouse and office building.
N-1738. Laborers' range closet.
N-1741. Water-closet and lavatory.
N-1743. Belt house.
N-1744. 3 type 14 quarters.
N-1745. Retaining wall and drain.
N-1746. Fumigation house.
N-1747. 1 type 18 dormitory.
N-1749. Ice platform.
N-1750. Laborers' sick camp.
N-1751. 1 type 17 quarters.
N-1752. 2 type 14 quarters.
N-1753. 1 type 18 dormitory.
N-1754. 1 1-room schoolhouse.
N-1755. Powder and detonator house.
N-1756. Sanitary inspector's office.
N-1757. Lodge and assembly hall.
N-1758. Band stand.
N-1759. Oil storehouse.
N-1760. Coal box.
N-1761. Market.
N-1762. Venturi meter shed.

Cartagenois.—Two old French buildings repaired for quarters.

Cucuracha.—Five old French buildings repaired for quarters and new buildings constructed as follows:

N-508. Jail.
N-509. Pump shed.

Enterprise.—Two old French buildings repaired for quarters.

Rio Grande.—Following new buildings completed:

N-1932. Commissary.
N-1934. Commissary help's quarters.
N-1935. Yardmaster's office.
N-1936. Laborers' range closet.
N-1937. 2 single flush closets.
N-3593. Engine house.
N-3594. Oil house.
N-3597. Office and storehouse.
N-3598. Sand house.
N-3599. Storehouse.

Culebra.—Seven old French buildings repaired for quarters, hospital purposes, storehouse, hotel, etc., and new buildings constructed as follows:

N-609. 6 type 14 quarters.
N-612. Penitentiary annex.
N-616. Administration building annex.
N-618. Post-office.
N-621. 2 type 17 quarters.
N-622. 1 type 22 quarters.
N-623. 5 type 14 quarters.
N-624. Storehouse.
N-625. Transformer station.
N-626. Fumigation house No. 2.
N-627. 4 type 17 quarters.
N-628. 2 type 17 quarters.
N-629. 1 type 24 quarters.
N-631. Storehouse.
N-632. 1 type 10 quarters.
N-634. Gallows.
N-635. Market house.
N-637. 1 type 10 quarters.
N-638. 1 type 21 quarters.
N-639. Motor-car house.
N-640. Cabinetmakers' shop.
N-641. 1 type 10 quarters.
N-642. Commissary.
N-643. Hospital waiting shed.
N-644. Addition to vault, administration building.
N-645. Unloading platform.
N-646. 1 type 21 quarters.

Lirio.—At this point there was built:

N-3008. Powder and detonator house.

Cerro.—Buildings were completed as follows:

N-3583. 2 powder and detonator houses.
N-3544. 2 laborers' range closets.

Empire.—Twenty-two old French buildings repaired for quarters, offices, storehouses, etc., and the following new buildings erected:

N-1043. Closet for white men.
N-1047. Machine shop.
N-1048. Transfer-table pit.
N-1049. Boiler shop.
N-1050. Blacksmith shop.
N-1051. Erecting shop.
N-1052. Car-repair shop.
N-1053. Planing mill.
N-1054. Schoolhouse.
N-1055. 5 type 18 dormitories.
N-1056. 1 laborers' range closet.
N-1061. 10 type 14 quarters.
N-1066. 10 type 14 quarters.
N-1067. Lavatory building.

N-1068. Storehouse.
N-1069. 1 type 10 quarters.
N-1070. 1 type 10 quarters.
N-1071. Transformer house.
N-1074. Sand house.
N-1075. Fire department building.
N-1077. Oil storehouse.
N-1078. Commissary.
N-1079. 2 type 14 quarters (by contract).
N-1080. 1 type 20 quarters.
N-1081. Paint shop.
N-1082. Hospital waiting shed.
N-1083. Oil storehouse.
N-1084. Colored schoolhouse.
N-1086. Footbridge.

Cunette.—Five old French buildings repaired for quarters, and new buildings completed as follows:

N-4022. 2 standard laborers' barracks.
N-4025. 2 laborers' bath houses.

Casa Blanca.—At this point there was completed,

N-4011. Laborers' bath house.

Las Cascadas.—One old French building repaired for quarters and the following new structures completed:

N-1513. 1 type 18 dormitory.
N-1516. Vault for disbursing office.
N-1522. Commissary.
N-1523. 10 type 14 quarters.
N-1524. Fire department building.
N-1525. Car-repair shed.
N-1526. Market and storehouse.
N-1528. Hotel help's quarters.
N-1529. Powder and detonator house.
N-1530. Corral.
N-1532. 1 2-room schoolhouse.
N-1533. Band stand.
N-1534. 2 type 14 buildings.
N-1535. Watch inspector's house.
N-1536. Office building.
N-1537. Hospital waiting shed.
N-1539. 1 type A jail.

Buena Vista.—Two old French buildings repaired for quarters.

Haut Obispo.—At this point there was erected:

N-3106. Powder and detonator house.

Camp Elliott.—At this point, which is occupied as a camp by the United States marine battalion stationed on the Isthmus, work on quarters, corral, gymnasium, storehouse, etc., was done at a cost of $10,000, which was defrayed from the funds of the United States Marine Corps.

Bas Obispo.—Eight old French buildings repaired for quarters and the following new work completed:

N-158. Mess hall.
N-159. 1 standard laborers' barracks.
N-164. 1 type 18 dormitory.
N-166. Corral.
N-167. 1 type 17 quarters.
N-168. 1 type 14 quarters.
N-169. Whirling apparatus.
N-170. Ice platform.
N-171. Powder and detonator house.
N-172. 1 1-room schoolhouse.
N-173. Sand house.
N-174. Storehouse.
N-175. Band stand.

Alhajuela.—At this point there was constructed:

N-3522. Hydrographer's kitchen.

Gamboa.—The following new building was constructed at this point:

N-3134. Yardmaster's office.

Chagres.—Three old French buildings repaired for quarters.

Santa Cruz.—Fifteen old French buildings repaired for quarters, mess hall, storehouses, etc., and new buildings constructed as follows:

N-4101. Powder shed.
N-4102. Washout shed.
N-4103. Three laborers' range closets.

Matachin.—Four old French buildings repaired for quarters, at this point, and new work completed as follows:

N-1413. Storehouse.
N-1414. Storage shed.
N-1415. Powder shed.
N-1416. Shop.
N-1417. Office.

Bas Matachin.—Ten old French buildings repaired for quarters, shops, etc., and following new work completed:

N-115. Paint shop.
N-121. Standard laborers' kitchen.
N-123. Extension of boiler shop.
N-125. European mess hall and kitchen.
N-126. Two standard laborers' barracks.
N-127. Two range closets.
N-128. Two laborers' washhouses.
N-129. Two range closets.
N-130. Oil-house addition.

Among the French buildings repaired at this point is a warehouse 50 by 250 feet, which was raised, moved, and repaired at a cost of $12,674.13. It is now valued at $20,000, and compares favorably with the best storehouses on the Isthmus.

Gorgona.—New buildings have been completed as follows:

N-1203. Lodge and assembly hall.
N-1204. 1 type 18 dormitory.
N-1207. Closet for white men and women.
N-1208. 1 range closet.
N-1209. 10 type 14 quarters.
N-1210. 3 type 18 dormitories.
N-1211. Post-office.
N-1212. Office and storeroom.
N-1213. Fumigation house.
N-1214. 3 type 18 dormitories.
N-1215. 3 type 14 quarters.
N-1216. Fire station.
N-1218. Commissary addition.
N-1220. 1 type 14 quarters.
N-1221. 1 type 17 quarters.
N-1222. 1 type 21 quarters.
N-1223. Hospital waiting shed.
N-1224. Footbridge.
N-1225. Wagon bridge.
N-1226. Pump shed.

Caballo Viejo.—Four old French buildings repaired for quarters.

Coco Lane.—Five old French buildings repaired for quarters and new work completed, as follows:

N-5100. Laborers' cook shed.
N-5101. Laborers' washhouse.

Caimito Mulato.—Nineteen old French buildings repaired for quarters, mess hall, etc., and new work completed, as follows:

N-4120. Standard laborers' kitchen.
N-4121. Powder house.
N-4122. Laborers' range closet.
N-4123. Laborers' washhouse.
N-4124. Washout shed.

San Pablo.—Fourteen old French buildings repaired for quarters, dispensary, schoolhouse, etc., and new work completed as follows:

N-3351. 1 type 17 quarters.
N-3352. 1 type 5 quarters (bachelor).
N-3353. Blacksmith shop.
N-3354. Hotel and mess hall.

N-3355. Standard laborers' kitchen.
N-3356. Laborers' bath house.
N-3357. Laborers' range closet.
N-3358. 2 laborers' washhouses.
N-3359. Washout shed.
N-3360. Blacksmith and work shop.
N-3361. Unloading platform.

Barbacoas.—One building repaired for occupancy by silver employees.

Tabernilla.—New work completed as follows:

N-3027. 1 laborers' range closet.
N-3032. Car-repair shed.
N-3033. 1 type 14 quarters.
N-3034. Sick camp for laborers.
N-3035. 1 type 18 dormitory.
N-3037. Storehouse.
N-3038. Ice platform.
N-3039. 2 cinder pits.
N-3041. Rain-gauge fence.
N-3042. Water-distilling shed.
N-3043. Fire-department building.
N-3438. 1 type 18 dormitory.
N-3461. Commissary building.
N-3462. Power shed.
N-3463. Oil shed.
N-3464. Office.
N-3465. Water-closet.
N-3467. Market.

Bohio.—Eighteen old French buildings repaired for quarters.

Gatun.—Four old French buildings repaired for quarters and new work completed as follows:

N-4037. 6 range closets.
N-4038. Schoolhouse for white children.
N-4046. Type 18 dormitory.
N-4047. 5 type 14 quarters.
N-4052. 1 laborers' bath house.
N-4054. 1 standard laborers' barracks.
N-4055. 1 type 5 quarters.
N-4056. Corral.
N-4058. Gallego mess hall and kitchen.
N-4063. Fire department building.
N-4064. Laborers' closet and bath.
N-4066. Storehouse.
N-4069. Laundry and drying room for laborers.
N-4070. Office.
N-4071. Laborers' range closet.
N-4072. 2 type 14 quarters.
N-4073. Range closet for men and women.
N-4074. 1 type 20 quarters.
N-4075. 1 type 20 quarters.
N-4076. Laborers' washhouse.
N-4079. Laborers' bath house.

Mindi.—At this point there was completed during the year:

N-4132. Warehouse.

Mount Hope.—Eight old French buildings have been repaired as quarters, storehouses, hospital buildings, etc., and new work completed as follows:

N-1704. Filter plant.

Cristobal Colon and Fox River.—Thirty old French buildings repaired as quarters, storehouses, hospital buildings, etc., and new work completed as follows:

N-269. Rest house for Salvation Army.
N-325. 2 laborers' bath houses.
N-326. 1 type 14 quarters.
N-327. Band stand.
N-328. Storehouse.
N-330. 7 type 14 quarters.
N-331. Hotel help's quarters.

N-333. Laundry and dry room for laborers.
N-334. 4 type 14 quarters.
N-335. Post-office.
N-336. Shed over sump hole.
N-337. 1 type 17 quarters.
N-338. Storage shed.
N-339. 1 type 18 dormitory.
N-340. Sewer pumping station.
N-341. Extension dry-dock shop.
N-343. 1 type 14 quarters (by contract).
N-344. 1 type 14 quarters.
N-345. Mareograph house.
N-246. Garbage house for hotel.

Porto Bello.—New work was completed at this point, which is about 18 miles from Cristobal, as follows:

N-4080. 2 standard laborers' barracks.
N-4081. 1 laborers' kitchen.
N-4082. 1 type 17 quarters.
N-4083. 1 type 5 quarters.
N-4084. Dining-room shed.
N-4085. 2 standard laborers' barracks.
N-4086. 1 type 18 dormitory.
N-4088. Office building.
N-4091. 2 standard laborers' barracks.

Old French buildings mentioned as having been repaired in the above statement of work have not before been used by the Isthmian Canal Commission, but have remained as they were received from the old French Company, the repairs referred to being initial repairs. Throughout the entire division, from Taboga to Porto Bello, many old French buildings have received initial repairs during previous years and have again been repaired on account of deterioration or alterations being made, and also many American buildings have been repaired for similar reasons.

The cost of preparation of pay rolls for this division, per name, was $0.33, and for issuing commissary and hotel books, per name, $0.11. These figures covered an average pay roll containing 1,800 names.

Plumbing fixtures installed, fiscal year 1907–8

	Closets.	Lavatories.	Sinks.	Showers.	Urinals.	Bath tubs.	Laundry tubs, sets.	Boilers.	Sinks, cast-iron.	Range closets, pairs.
266 new installations	930	892	689	887	79	42	27	29	124	92½
Alterations on 91 new Isthmian Canal Commission buildings	46	68	47	25	2	6	5	10	3	......
Alterations on 95 French buildings	77	76	94	70	3	10	4	8	......	......
New plumbing installed in 66 French buildings	66	55	54	62	2	......	......	1	3	½
Plumbing installed in 6 tugs and dredges	11	37	3	5	......	......	......	......	......	......
Total	1,130	1,128	887	1,049	86	58	36	48	130	93

New Isthmian Canal Commission buildings, plumbing installed	266
Isthmian Canal Commission buildings, plumbing altered	91
French buildings, plumbing altered	95
French buildings, new plumbing installed	66
Tugs and dredges, plumbing installed	6
Total	524
Total number of repairs made on Isthmian Canal Commission buildings	3,234
Total number of repairs made on French buildings	2,632

Cost of standard articles manufactured at the Lirio planing mill (including labor and material, but no hardware)—Continued.

Blinds, F:	
Single—	
1 foot 6 inches by 5 feet	$1.09
1 foot 9 inches by 4 feet 4 inches	1.06
1 foot 9 inches by 5 feet 4 inches	1.09
2 feet by 4 feet	1.46
2 feet by 5 feet	1.60
Pair—	
2 feet 6 inches by 4 feet 4 inches	2.10
3 feet by 3 feet 4 inches	2.03
3 feet by 3 feet 6 inches	1.40
3 feet by 5 feet	2.74
3 feet 6 inches by 4 feet 4 inches	2.12
3 feet 6 inches by 5 feet 4 inches	2.18
Doors, D:	
Single, 2 feet by 8 feet	4.50
Panel, $1\frac{3}{8}$ inches thick—	
2 feet 6 inches by 7 feet	3.35
2 feet 6 inches by 8 feet	3.40
2 feet 8 inches by 7 feet	3.35
2 feet 8 inches by 8 feet	3.60
3 feet by 8 feet	4.50
Doors, E:	
Slat, $1\frac{3}{8}$ inches thick—	
2 feet 6 inches by 7 feet	3.00
2 feet 6 inches by 8 feet	2.90
2 feet 8 inches by 7 feet	3.49
2 feet 8 inches by 8 feet	3.55
3 feet by 8 feet	4.25
Doors, I, pair:	
Slat, $1\frac{3}{8}$ inches thick—	
3 feet by 8 feet	5.66
3 feet 6 inches by 8 feet	6.02
Screen, single, $1\frac{1}{8}$ inches thick—	
2 feet 8 inches by 7 feet	2.59
2 feet 8 inches by 8 feet	2.57
3 feet by 8 feet	2.14
W. C. No. 6, single—	
2 feet by 5 feet	1.10
2 feet 4 inches by 5 feet	1.10
Sash, L:	
Single—	
1 foot 3 inches by 3 feet 6 inches	.53
1 foot 6 inches by 3 feet 4 inches	.90
1 foot 6 inches by 5 feet	1.12
1 foot 9 inches by 4 feet 4 inches	1.20
1 foot 9 inches by 5 feet 4 inches	1.17
2 feet by 3 feet 6 inches	1.00
2 feet by 4 feet	1.21
2 feet by 5 feet	1.30
Pair—	
3 feet by 3 feet 4 inches	1.80
3 feet by 4 feet	2.04
3 feet by 5 feet	2.24
3 feet 6 inches by 4 feet 4 inches	2.40
3 feet 6 inches by 5 feet 4 inches	2.34
Sash, transom, single:	
3 feet by 2 feet 3 inches	1.04
3 feet 6 inches by 2 feet 3 inches	.75
Lattice, screen, single:	
1 foot 6 inches by 8 feet	5.00
3 feet by 8 feet	7.46
Molding, $\frac{7}{8}$ inch, quarter round .... M linear feet	5.00

Cost of standard articles manufactured at the Lirio planing mill (including labor and material, but no hardware)—Continued.

Casing:		
3½ inches	M linear feet	$20.00
4 inches	do	20.00
4½ inches	do	20.00
5½ inches	do	20.00
Strips:		
½ inch by 1 inch	do	4.00
1 inch by 3 inches	do	20.00
½ inch by 2 inches	do	5.00
Door stops:		
2-wire molding	do	11.00
2-wire capping	do	8.00
3-wire molding	do	15.00
3-wire capping	do	10.00

Comparative statement of expenditures on account of pay rolls for fiscal years 1906–7 and 1907–8, division of building construction.

	1906–7.	1907–8.
Indirect labor:		
Office, superintendents, etc	$197,403.94	$190,226.94
Sick leave	7,427.27	37,483.51
Transit time	82,767.02	1,571.37
Vacation leave	26,813.93	29,199.90
Holiday pay	15,429.68	31,904.63
Meritorious sick leave	1,355.18	4,231.85
Band practice	44.29	48.93
Court attendance	11.62	59.00
Total indirect labor charges	281,252.93	294,726.13
Direct labor	2,278,990.22	1,566,566.90
Total of rolls	2,560,243.15	1,861,293.03

Statement of buildings repaired and constructed, demolished, remaining, and totals, from July 1, 1907, to June 30, 1908.

Town or railroad station.	Buildings on hand July 1, 1907.	Previously repaired.	Repaired this year.	Destroyed.	Balance to be repaired.	Previously constructed.	Constructed this year.	Class of construction.	On hand June 30, 1908.
Palo Seco	8					8			8
Taboga	9	2			6	1	1	Sanitarium	10
Naos	3	1			2				3
Flamenco	2					2			2
Culebra Island							9	Quarantine station	9
Farfan	3				3				3
La Boca	89	36	16	2		35	18	1 office building, 9 quarters, 1 hospital shed, 1 mess hall, 1 commissary, 5 storehouses.	105
Panama	4	2		1		1			3
La Section	24	8			15	1			24
Ancon	175	65	23	2		85	65	39 quarters, 16 hospital buildings, 1 post-office, 1 storehouse, 1 fumigation house, 1 filter plant, 1 fire-department building, 1 schoolhouse, 1 washhouse, 1 meter shed, 1 telephone exchange, 1 band stand.	238
Las Sabanas	1					1	1	1 jail privy	2
Corozal	54	31				23	13	1 fire-department building, 6 quarters, 1 jail, 1 corral, 2 office buildings, 1 fumigation house, 1 storehouse.	67
Rio Grande Inferior	7				7				7
Butte Cardenas	2				2				2
Ecluse 10	13				13				13
Miraflores	31	28	3				4	2 quarters, 1 mess hall, 1 storehouse.	35
Pedro Miguel Tank	21	7			14				21
Ecluse 9	11				11				11
Pedro Miguel	51	9	9			33	20	10 quarters, 2 shops, 4 storehouses, 1 market, 1 platform, 1 fumigation house, 1 hospital shed.	71
Forty-mile Siding	30	10		10		10			20
Kilometer 58,600	3				3				3
Ecluse 7 and 8	1				1				1
Ecluse 8	7				7				7
Paraiso	136	57	15	7		57	29	7 shop buildings, 9 quarters, 1 vault, 1 platform, 1 fumigation house, 1 sick camp, 1 schoolhouse, 3 storehouses, 1 office, 1 lodge hall, 1 band stand, 1 market, 1 venturi meter shed.	158
Cartagenois	32	22	2			8			32
Ecluse 7	7				7				7
Cucaracha	30	25	5			9	2	1 jail, 1 pump shed	41
Enterprise	32	2	2	7		21			25
Rio Grande	33	5		1		27	10	3 shop buildings, 2 storehouses, 1 commissary, 3 quarters, 1 office.	42
Cerro Germain	17	8				9			17
Cerro Lirio	40	40							40
Culebra	207	80	7	5		115	41	26 quarters, 1 office building, 2 storehouses, 1 transformer station, 1 fumigation house, 1 gallows, 1 motor-car house, 1 shop, 1 commissary, 1 jail annex, 1 hospital shed, 1 platform, 1 vault addition, 1 post-office, 1 market.	243
Lirio	34	27				7	1	1 storehouse	35

Statement of buildings repaired and constructed, demolished, remaining, and totals, from July 1, 1907, to June 30, 1908—Continued.

Town or railroad station.	Buildings on hand July 1, 1907.	Previously repaired.	Repaired this year.	Destroyed.	Balance to be repaired.	Previously constructed.	Constructed this year.	Class of construction.	On hand June 30, 1908.
Cerro	26	21				5	4	2 storehouses, 2 quarters	30
Empire	168	64	22	2		80	52	33 quarters, 7 shop buildings, 2 schoolhouses, 5 storehouses, 1 transformer station, 1 fire-department building, 1 commissary, 1 hospital waiting shed, 1 footbridge.	218
Cunette	63	40	5			9	4	4 quarters	67
Casa Blanca	39	36				3	1	1 quarters	40
Las Cascadas	98	53	1	1		43	27	15 quarters, 1 vault, 1 commissary, 1 fire-department building, 1 shop building, 2 hospital buildings, 1 storehouse, 1 corral, 1 schoolhouse, 1 band stand, 1 office building, 1 jail.	124
Buena Vista	50	43	5			2			50
Haut Obispo	69	56		1		12	4	2 storehouses, 1 corral, 1 gymnasium.	72
Ras Obispo	66	45	6	4		9	13	1 mess hall, 4 quarters, 1 corral, 1 whirling apparatus, 1 platform, 3 storehouses, 1 schoolhouse, 1 band stand.	75
Alhajuela	8	2			5	1	1	1 kitchen	9
Cruses	5				5				5
Las Delicias	5				5				5
Gamboa	34	22				12	1	1 office	35
Chagres	33	20	3	2		8			31
Santa Cruz	62	43	15	3		1	5	3 closets, 2 shop buildings	64
Matachin	13	7	4			2	5	3 storehouses, 1 shop building, 1 office building.	18
Ras Matachin	82	34	10	2		36	13	3 shop buildings, 1 mess hall, 2 wash houses, 6 quarters, 1 S. D. kitchen.	93
Kilometers 43,200 to 44,000	11				11				11
Kilometer 1,000	11				11				11
Gorgona Campment	[illegible]	39		3		44	54	54 quarters, 1 lodge hall, 1 [illegible], 1 fumigation house, 1 commissary addition, 1 hospital shed, 1 [illegible] 1 [illegible] 1 fire-department [illegible].	107
[illegible]	32	21			11				32
[illegible]	4				4				4
[illegible]	29	14	4			[illegible]			29
[illegible]	[illegible]	[illegible]				5			15
[illegible]	14	8				6			14
[illegible]	[illegible]				[illegible]				5
[illegible]	[illegible]				[illegible]				2
[illegible]	[illegible]		3		[illegible]		[illegible]	[illegible]	20
[illegible]	[illegible]		[illegible]	[illegible]			[illegible]	3 [illegible]	34
[illegible]	[illegible]				14				14
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	35
[illegible]	[illegible]				[illegible]				2
[illegible]	[illegible]		[illegible]		[illegible]				[illegible]
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	4 [illegible]	[illegible]
[illegible]	[illegible]	[illegible]							[illegible]

Statement of buildings repaired and constructed, demolished, remaining, and totals, from July 1, 1907, to June 30, 1908.—Continued.

Town or railroad station.	Buildings on hand July 1, 1907.	Previously repaired.	Repaired this year.	Destroyed.	Balance to be repaired.	Previously constructed.	Constructed this year.	Class of construction.	On hand June 30, 1908.
Sin La Voie du Kilometer 29.	6	5				1			6
Chagres	12				12				12
Frijoles	3	2				1			3
Chagres	33				33				33
Bohio	47	20	18		9				47
New Town	1				1				1
Derivation 4	5				5				5
Ecluse 1	18				18				18
Derivation 3	3				3				3
Penas Blancas Arriba	3				3				3
Penas Blancas Q. L.	7				7				7
Vamos Vamos	1				1				1
Gatun	97	1	4			92	32	2 office buildings, 24 quarters, 1 storehouse, 1 corral, 1 mess hall, 1 fire-department building, 1 schoolhouse, 1 laundry, and dry room.	129
Mindi	3				3		1	1 warehouse	4
Mount Hope	24	7	8		4	5	1	1 filter plant.	25
Cristobal, Colon & Fox River.	318	129	30	9	57	93	30	1 rest house, 19 quarters, 1 band stand, 1 schoolhouse, 1 laundry and dry room, 1 post-office, 1 shed, 1 office building, 1 shop building, 1 storehouse, 1 marigraph house, 1 garbage house.	339
Porto Bello							12	11 quarters, 1 office building.	12
Totals	2,919	1,252	258	97	341	971	491		3,313

Personnel.

There have been very few changes during the year in the personnel of this department, which remains as follows:

Division of motive power and machinery:
- Mr. Geo. D. Brooke, superintendent of motive power and machinery.
  - Mr. E. J. Banta, mechanical engineer.
  - Mr. A. L. Robinson, electrical engineer.
  - Mr. E. C. Cummings, master mechanic, Gorgona shops.
  - Mr. W. O. Johnson, master mechanic, Empire shops.
  - Mr. E. C. Harington, master mechanic, Paraiso shop.

Division of municipal engineering:
- Mr. J. G. Holcombe, division engineer.
  - Mr. W. M. Acheson, assistant engineer, Panama residency.
  - Mr. C. T. Waring, assistant engineer, Empire residency.
  - Mr. L. G. Thom, assistant engineer, Gatun residency.
  - Mr. C. W. Beattie, assistant engineer, Cristobal residency.

Division of building construction:
- Mr. W. M. Belding, master builder.
  - Mr. P. O. Wright, jr., architect.
  - Mr. S. D. Morgan, superintendent of painting.
  - Mr. C. L. Stockleberg, superintendent of plumbing.

Division of building construction—Continued.

Mr. W. M. Belding, master builder—Continued.

Mr. W. C. Dotson, superintendent of masonry.
Mr. L. M. Lippsett, superintendent, carpentry work, Ancon district.
Mr. J. P. Kyte, superintendent, carpentry work, Pedro Miguel district.
Mr. J. F. Wickham, superintendent, carpentry work, Culebra district.
Mr. H. E. Daly, superintendent, carpentry work, Gorgona district.
Mr. W. H. Storm, superintendent, carpentry work, Cristobal district.

Very respectfully,

H. H. Rousseau,
Civil Engineer, U. S. Navy,
Head of Department of Motive Power and Machinery,
Municipal Engineering, and Building Construction.

Lieut. Col. Geo. W. Goethals,
U. S. Army, Corps of Engineers,
Chairman and Chief Engineer,
Isthmian Canal Commission, Culebra, Canal Zone.

Appendix 1.

CHEMICAL AND BACTERIOLOGICAL REPORT ON WATER SUPPLIES OF THE CANAL ZONE.

By James O. Meadows, *Physiologist.*

In 1906 a deep well was sunk at Mount Hope, but the water obtained from this well was very hard, so that its use was not practical. The drilling of more wells was discouraged by this trial and surface supplies were depended upon.

The rivers of the Canal Zone are very turbid during the wet season and, as their watersheds are populated, they would not prove a feasible supply unless they were subjected to filtration. A large portion of the Canal Zone is now furnished with water from 4 reservoirs, namely, Rio Grande, Camacho, Carabali, and Brazos Brook. As these four supplies are of a permanent nature, a majority of the work has been confined to them. The chemical and bacteriological work performed was carried out in accordance with the methods laid down by the American Public Health Association, Volume XXX, Part II.

All four watersheds are free from human inhabitants, so that the danger from human pollution is very small. The watersheds are all covered with a dense growth of vegetation and many wild animals inhabit the area. At the begining of the work, in November, 1907, all the reservoirs were full and had been so for about two months.

The changes which take place in the water supplies during a year may be said to form a cycle, starting with the wet season, carrying the work through the dry season, and then into the rainy period again.

TABLE 1.—*Table of chemical data, showing also rainfall and elevation of water.*

Sample No.	Date.	Source.	Parts per million.										Loss on ignition.	Rainfall.	Elevation of water.
			Color.	Alkalinity.	Chlorin.	Oxygen constituents.	Nitrogen as—				Iron.	Total solids.			
							Free ammonia.	Albuminoid ammonia.	Nitrites.	Nitrates.					
	1907.													*Inches.*	*Feet.*
1	Nov. 2	Rio Grande Reservoir	45	46	2.0	3.4	0.050	0.232	None.	Trace.	0.4	100	32	....	232.52
2	...do....	Camacho Reservoir	23	52	2.0	3.5	.051	.294	None.	Trace.	.2	107	37	....	365.30
3	...do....	Brazos Brook Reservoir	25	28	4.0	5.4	.035	.320	None.	Trace.	.4	83	43	....	45.10
4	Nov. 9	Gorgona Reservoir	20	58	3.0	3.0	.050	.362	None.	Trace.	.1	145	41	3.36	....
5	...do....	Brazos Brook Reservoir	25	29	4.0	5.5	.018	.344	None.	Trace.	.1	92	42	5.14	45.20
6	...do....	Cristobal tap	25	28	4.0	4.1	*a*.174	.300	None.	0.1	.1	85	30	....	....
7	Nov. 16	Rio Grande Reservoir	30	45	1.0	4.3	.047	.231	None.	Trace.	.3	103	41	6.09	235.22
8	...do....	Camacho Reservoir	20	54	1.5	3.8	.043	.214	None.	Trace.	.1	111	46	5.06	365.40
9	...do....	Brazos Brook Reservoir	23	28	3.5	4.3	.027	.324	None.	.07	1.0	90	48	3.22	45.00
10	Nov. 20	Gorgona Reservoir	25	62	3.0	3.7	.028	.388	None.	Trace.	.1	137	47	3.16	....
11	Nov. 22	Rio Grande Reservoir	22	46	1.0	4.2	.028	.210	None.	Trace.	.3	97	15	1.04	236.62
12	...do....	Camacho Reservoir	18	55	1.0	4.3	.028	.200	None.	Trace.	.2	104	17	1.15	365.00
13	...do....	Brazos Brook Reservoir	25	30	3.0	4.3	.232	.300	None.	.04	2.2	83	17	3.49	45.10
14	Nov. 26	Gorgona Reservoir	25	62	3.0	2.7	.068	.288	None.	.15	.8	136	24	3.33	....
15	Nov. 29	Rio Grande Reservoir	23	45	1.5	4.2	.052	.234	None.	Trace.	.7	104	31	1.10	237.33
16	...do....	Camacho Reservoir	18	55	1.0	3.9	.052	.218	None.	Trace.	.2	103	28	2.60	365.20
17	...do....	Brazos Brook Reservoir	15	27	3.0	5.1	.034	.384	None.	01	1.2	91	41	1.13	45.00
18	Dec. 3	Gorgona Reservoir	20	65	3.0	2.9	.032	.276	None.	.07	.2	144	62	.29	....
19	Dec. 6	Rio Grande Laboratory tap	48	46	1.0	3.9	.060	.305	None.	.07	4.0	147	34	....	237.64
20	...do....	Camacho Reservoir	20	56	1.0	2.1	.054	.268	Trace.	Trace.	.1	106	23	.23	364.60
21	...do....	Brazos Brook Reservoir	25	27	3.5	5.4	.032	.400	None.	.01	1.1	81	44	2.63	45.00
22	Dec. 10	Gorgona Reservoir	20	70	3.5	3.0	.024	.468	Trace.	.01	.2	134	36	.97	....
23	Dec. 13	Rio Grande Reservoir	20	50	1.0	3.1	.072	.200	Trace.	Trace.	.4	96	28	1.61	238.12
24	...do....	Camacho Reservoir	16	58	1.0	3.4	.128	.282	Trace.	Trace.	.5	100	26	1.51	364.40
25	...do....	Brazos Brook Reservoir	25	28	3.5	5.9	.152	.484	Trace.	.01	3.5	90	45	2.64	45.10
26	Dec. 17	Gorgona Reservoir	18	74	4.0	2.5	.068	.484	Trace.	Trace.	.2	146	38	.07	....
27	Dec. 21	Rio Grande Reservoir	12	56	2.0	2.6	.118	.384	0.001	.01	.2	110	38	.05	273.96
28	...do....	Camacho Reservoir	13	58	2.0	2.7	.156	.383	.001	.01	.2	105	33	.20	364.10
29	...do....	Brazos Brook Reservoir	48	28	3.5	6.0	.136	.440	Trace.	.02	1.3	92	51	.25	44.90
30	...do....	Mindi pumping station	32	27	11.0	5.3	.128	.472	Trace.	.03	1.4	102	42	....	....
	1908.														
31	Jan. 3	Rio Grande Reservoir	16	61	3.0	2.9	.056	.176	Trace.	Trace.	.3	107	31	.78	237.42
32	...do....	Camacho Reservoir	15	63	3.0	3.4	.068	.176	Trace.	Trace.	.2	102	28	.21	363.50
33	...do....	Brazos Brook Reservoir	22	31	4.0	4.9	.084	.372	Trace.	Trace.	1.3	79	43	.16	43.90

34	Jan. 7	Gorgona Reservoir	25	80	4.0	5.7	.040	.328	Trace.	Trace.	.5	149	36	.93	....
35	...do....	Gatuncillo River	12	83	4.0	1.7	.040	.236	Trace.	None.	.4	135	19	....	....
36	Jan. 10	Rio Grande Reservoir	10	62	3.0	3.8	.068	.192	Trace.	None.	.2	101	20	.20	230.97
36a	...do....	Rio Grande Reservoir (filtered)	10	62	3.0	3.8	.100	.164	Trace.	None.	.2	111	30	....	....
37	...do....	Camacho Reservoir	10	66	3.0	3.4	.056	.162	Trace.	.001	.1	106	27	.11	363.10
37a	...do....	.....do............(filtered)	10	66	3.0	3.0	.108	.208	Trace.	.001	.1	109	29	....	....
38	...do....	Brazos Brook Reservoir	28	32	4.0	7.3	.100	.368	Trace.	.002	.1	84	34	1.78	43.50
38a	...do....	.....do............(filtered)	28	32	4.0	5.3	.110	.164	Trace.	.002	.5	76	29	....	....
39	Jan. 24	Gorgona Reservoir	12	88	5.0	3.9	.104	.472	Trace.	Trace.	.4	144	22	.08	....
39a	...do....	.....do............(filtered)	12	88	5.0	3.2	.144	.312	Trace.	Trace.	.3	138	33	....	....
40	...do....	Paraiso Springs	5	50	6.5	1.1	.108	.208	None.	Trace.	.3	85	11	....	....
41	Jan. 29	Rio Grande Reservoir	7	66	3.5	1.5	.024	.164	Trace.	None.	.2	118	30	.55	235.61
42	...do....	Rio Grande (laboratory tap)	7	66	3.5	2.0	.024	.264	Trace.	None.	.2	118	27	....	....
43	...do....	Camacho Reservoir	5	68	3.5	2.7	.032	.120	Trace.	None.	.2	118	33	1.59	361.90
44	...do....	Brazos Brook Reservoir	35	32	4.0	5.7	.052	.580	Trace.	Trace.	.7	89	45	2.37	42.20
45	Feb. 13	Rio Grande Reservoir	14	66	3.5	1.6	.068	.416	Trace.	None.	.4	110	27	....	234.12
46	...do....	Camacho Reservoir	10	68	3.5	1.3	.084	.436	Trace.	None.	.3	112	28	....	360.50
47	...do....	Gorgona Reservoir	14	89	5.0	3.5	.072	.548	Trace.	None	.4	153	45	.04	....
48	...do....	Brazos Brook Reservoir	45	30	5.0	6.7	.112	.632	Trace.	Trace.	1.5	84	46	.45	41.00
49	Feb. 28	Camacho Reservoir	8	72	3.5	2.3	.100	.264	Trace.	Trace.	.3	111	23	.00	359.20
49a	...do....	Camacho Reservoir (35 feet deep)	10	72	3.5	2.1	.160	.254	Trace.	Trace.	.3	114	25	....	....
50	...do....	Rio Grande Reservoir	10	68	3.5	1.7	.084	.268	Trace.	None.	.3	112	23	....	232.43
50a	...do....	Rio Grande Reservoir (40 feet deep)	65	68	3.5	3.2	.208	.352	Trace.	None.	2.5	120	24	....	....
51	...do....	Gorgona Reservoir	17	94	5.0	3.7	.132	.604	Trace.	None.	.5	154	35	.07	....
51a	...do....	Gorgona Reservoir (20 feet deep)	20	96	5.5	3.6	.340	.508	.01	None.	1.0	160	32	....	....
52	...do....	Brazos Brook Reservoir	70	33	5.0	6.4	.172	.728	Trace.	Trace.	2.0	88	39	.70	39.90
52a	...do....	Brazos Brook Reservoir (20 ft. deep)	90	33	5.0	6.4	.312	.788	Trace.	Trace.	2.2	85	37	....	....
53	Mar. 12	Rio Grande Reservoir	10	72	4.0	2.0	.052	.208	Trace.	None.	.3	117	24	.01	230.77
54	...do....	Camacho Reservoir	10	74	3.5	2.0	.020	.216	Trace.	None.	.3	112	27	.01	357.70
55	...do....	Gorgona Reservoir	12	98	5.0	4.6	.048	.420	Trace.	None.	.5	159	41	.09	70.30
56	...do....	Brazos Brook Reservoir	106	34	5.0	6.1	.060	.384	Trace.	Trace.	2.0	96	45	.84	38.70
57	Mar. 24	Rio Grande Reservoir	25	72	4.0	2.9	.132	.208	None.	None.	.3	115	21	.02	229.12
58	...do....	Camacho Reservoir	5	76	4.0	2.6	.084	.260	Trace.	None.	.4	118	24	.24	356.40
59	...do....	Gorgona Reservoir	8	101	6.0	4.6	.128	.368	None.	None.	.5	161	30	.19	69.40
60	Mar. 25	Brazos Brook Reservoir	110	35	5.5	7.8	.164	.492	None.	Trace.	3.0	94	39	2.08	37.90
61	Apr. 8	.....do	98	37	5.5	7.0	.128	.540	None.	Trace.	3.0	90	37	.44	36.60
62	Apr. 9	Rio Grande Reservoir	17	74	4.0	2.5	.076	.234	Trace.	None.	.3	118	25	.26	227.00
63	...do....	Camacho Reservoir	10	78	4.0	2.0	.068	.212	Trace.	None.	.4	113	21	.82	354.02
64	...do....	Gorgona Reservoir	14	107	6.0	5.7	.112	.476	None.	Trace.	.5	171	36	.23	68.35
65	Apr. 21	Rio Grande Reservoir	20	77	4.0	3.4	.056	.188	Trace.	None.	.3	133	27	....	225.25
66	...do....	Camacho Reservoir	8	82	4.0	2.9	.040	.202	Trace.	None.	.3	118	25	....	352.30
67	...do....	Gorgona Reservoir	22	114	6.0	5.5	.180	.468	Trace.	Trace.	.7	181	40	.02	66.80
68	Apr. 22	Brazos Brook Reservoir	98	38	5.5	6.9	.094	.396	None.	Trace.	3.5	96	40	.68	35.50
69	May 6	Rio Grande Reservoir	20	74	4.0	2.7	.100	.228	Trace.	None.	.3	118	31	4.87	224.87
70	...do....	Camacho Reservoir	10	80	4.0	3.3	.120	.252	Trace.	None.	.3	133	36	7.26	351.00
71	May 7	Gorgona Reservoir	25	83	6.0	7.8	.208	.540	.003	Trace.	.4	181	54	1.70	68.20
72	...do....	Brazos Brook Reservoir	105	38	5.5	7.5	.300	.528	Trace.	Trace.	3.3	115	55	2.36	34.20
73	May 14	Rain water	None.	3	1.0	....	None.	None.	Trace.	None.	None.	8	1	....	....
74	May 20	Rio Grande Reservoir	20	67	4.0	4.1	.072	.280	.003	None.	.2	113	26	5.84	228.47
75	...do....	Camacho Reservoir	15	73	4.0	4.2	.064	.408	.0005	None.	.3	115	29	8.62	351.50
76	...do....	Gorgona Reservoir	25	61	6.0	6.3	.180	.428	.0035	Trace.	.3	139	35	6.52	72.90

TABLE 1.—*Table of chemical data, showing also rainfall and elevation of water*—Continued.

Sample No.	Date.	Source.	Parts per million. Color.	Alkalinity.	Chlorin.	Oxygen constituunts.	Nitrogen as— Free ammonia.	Albuminoid ammonia.	Nitrites.	Nitrates.	Iron.	Total solids.	Loss on ignition.	Rainfall.	Elevation of water.
	1908.													*Inches.*	*Feet.*
77	May 21	Brazos Brook Reservoir	100	30	5.5	5.3	.292	.456	.001	Trace.	2.0	89	37	16.11	38.60
78	June 3	Rio Grande Reservoir	12	62	3.0	2.5	.100	.376	.0005	None.	2.0	118	40	3.78	229.22
79	...do...	Camacho Reservoir	10	70	3.0	3.9	.124	.356	.0005	None.	.3	114	46	6.22	352.00
80	...do...	Gorgona Reservoir	25	56	5.5	7.4	.132	.484	.0003	Trace.	.2	134	46	....	....
81	June 4	Brazos Brook Reservoir	55	28	4.5	4.8	.184	.436	.001	Trace.	1.2	82	37	4.73	40.20
82	June 17	Rio Grande Reservoir	10	60	3.0	3.7	.124	.356	.0005	None.	.2	109	26	....	....
83	...do...	Camacho Reservoir	18	65	3.0	4.5	.108	.412	Trace.	None.	.9	106	29	....	....
84	...do...	Gorgona Reservoir (top)	25	62	6.0	5.97	.144	.508	.0008	None.	.9	131	32	....	....
84a	...do...	Gorgona Reservoir (bottom)	25	72	6.0	6.7	.156	.596	Trace.	None.	.35	137	36	....	....
85	June 18	Brazos Brook Reservoir	48	29	5.5	5.6	.148	.612	.0005	Trace.	1.2	77	32	....	....

a The higher reading for free ammonia in sample 6 is due to the use of ammonia alum in the Mount Hope filtration plant. The rainfall given is the amount recorded between the dates given.

TABLE 2.—*Table showing bacterial content and quantity of sample in which B. coli is present.*

Sample No.	Date.	Source.	Cubic centimeters used.	Plate count.	Bacteria per cubic centimeter.	B. coli present in—	B. coli not present in—
	1907.						
7	Nov. 16	Rio Grande Reservoir	0.1	95	950	1.0	....
8	...do....	Camacho Reservoir	.1	190	1,900	1.0	....
9	...do....	Brazos Brook Reservoir	.05	675	13,500	2.0	....
10	Nov. 20	Gorgona Reservoir	.05	165	3,300	2.0	....
11	Nov. 22	Rio Grande Reservoir	.1	180	1,800	2.0	....
12	...do....	Camacho Reservoir	.1	6	60	....	2.0
13	...do....	Brazos Brook Reservoir	.05	1,125	22,500	.1	....
14	Nov. 26	Gorgona Reservoir	.1	12	120	2.0	....
18	Dec. 3	.....do	.1	130	1,300	....	1.0
19	Dec. 6	Rio Grande Reservoir	.1	51	500	1.0	....
20	...do....	Camacho Reservoir	.5	50	100	....	1.0
21	...do....	Brazos Brook Reservoir	.1	70	700	....	1.0
22	Dec. 10	Gorgona Reservoir	.2	110	550	....	1.0
23	Dec. 13	Rio Grande Reservoir	.2	58	300	....	1.0
24	...do....	Camacho Reservoir	.5	70	140	....	1.0
25	...do....	Brazos Brook Reservoir	.2	112	560	....	1.0
26	Dec. 17	Gorgona Reservoir	.5	210	420	....	1.0
27	Dec. 20	Rio Grande Reservoir	.5	950	1,900	....	1.0
28	...do....	Camacho Reservoir	.5	22	44	....	1.0
29	...do....	Brazos Brook Reservoir	.2	11	55	....	1.0
30	...do....	Mindi	.2	270	1,400	....	1.0
	1908.						
31	Jan. 3	Rio Grande Reservoir	.5	51	100	....	2.0
32	...do....	Camacho Reservoir	.5	48	100	....	2.0
33	...do....	Brazos Brook Reservoir	.2	20	100	2.0	....
34	Jan. 7	Gorgona Reservoir	.5	450	900	2.0	....
35	...do....	Gatuncillo River	.2	500	2,500	....	2.0
36	Jan. 10	Rio Grande Reservoir	.5	260	520	....	2.0
37	...do....	Camacho Reservoir	.5	25	50	....	2.0
38	...do....	Brazos Brook Reservoir	.2	95	480	....	2.0
39	Jan. 24	Gorgona Reservoir	.5	480	960	2.0	....
40	...do....	Paraiso Springs	.5	1,050	2,100	....	2.0
41	Jan. 29	Rio Grande Reservoir	.5	95	190	....	2.0
42	...do....	Rio Grande (laboratory tap)	.5	190	380	....	2.0
43	...do....	Camacho Reservoir	.5	120	240	....	2.0
44	...do....	Brazos Brook Reservoir	.5	98	200	....	2.0
45	Feb. 13	Rio Grande Reservoir	.5	700	1,400	....	2.0
46	...do....	Camacho Reservoir	.5	240	480	....	2.0
47	...do....	Gorgona Reservoir	.5	210	420	....	2.0
48	...do....	Brazos Brook Reservoir	.5	245	490	....	2.0
49	Feb. 28	Camacho Reservoir	1.0	200	200	....	10.0
50	...do....	Rio Grande Reservoir	.5	18	36	....	10.0
51	...do....	Gorgona Reservoir	.5	116	230	10.0	....
52	...do....	Brazos Brook Reservoir	5	87	170	....	10.0
53	Mar. 12	Rio Grande Reservoir	.5	32	64	10.0	....
54	...do....	Camacho Reservoir	.5	550	1,100	....	10.0
55	...do....	Gorgona Reservoir	.5	95	190	....	10.0
56	...do....	Brazos Brook Reservoir	.5	63	125	10.0	....
57	Mar. 24	Rio Grande Reservoir	.5	20	40	....	10.0
58	...do....	Camacho Reservoir	1.0	13	13	10.0	....
59	...do....	Gorgona Reservoir	1.0	175	175	10.0	....
60	Mar. 25	Brazos Brook Reservoir	1.0	30	30	10.0	....
61	Apr. 8	.....do	1.0	1,200	1,200	10.0	....
62	Apr. 9	Rio Grande Reservoir	1.0	80	80	....	10.0
63	...do....	Camacho Reservoir	1.0	130	130	10.0	....
64	...do....	Gorgona Reservoir	1.0	120	120	....	10.0
65	Apr. 21	Rio Grande Reservoir	1.0	130	130	....	10.0
66	...do....	Camacho Reservoir	1.0	250	250	10.0	....
67	...do....	Gorgona Reservoir	1.0	300	300	....	10.0
68	Apr. 22	Brazos Brook Reservoir	.1	350	3,500	10.0	....
69	May 6	Rio Grande Reservoir	.1	180	1,800	10.0	....
70	...do....	Camacho Reservoir	.1	130	1,300	1.0	....
71	May 7	Gorgona Reservoir	.05	140	2,800	10.0	....
72	...do....	Brazos Brook Reservoir	.05	260	5,200	10.0	....
74	May 20	Rio Grande Reservoir	.05	18	350	10.0	....
75	...do....	Camacho Reservoir	.05	98	2,000	.5	....
76	...do....	Gorgona Reservoir	.05	420	8,500	.5	....
77	May 21	Brazos Brook Reservoir	.05	95	1,900	.5	....
78	June 3	Rio Grande Reservoir	.1	18	180	10.0	....
79	...do....	Camacho Reservoir	.1	27	270	10.0	....
80	...do....	Gorgona Reservoir	.05	350	7,000	.1	....
81	June 4	Brazos Brook Reservoir	.1	112	2,200	1.0	....
82	June 17	Rio Grande Reservoir	.5	50	100	10.0	....
83	...do....	Camacho Reservoir	.5	150	300	1.0	....
84	...do....	Gorgona Reservoir (surface)	.1	210	2,100	.1	....
84a	...do....	.....do	.05	1,000	20,000	.02	....
85	June 18	Brazos Brook Reservoir	.05	220	4,400	10.0	....

During the wet season the large amount of water entering the reservoirs dilutes the water already present, and the mineral constituents are lowered. The watersheds being covered with a heavy growth of vegetation, the amount of material carried in suspension is not great and the turbidity of the water is low.

The wash from the watersheds carries into the reservoirs many forms of germ life, thus making the bacterial content of the waters comparatively high during this period.

The organic content of the 4 reservoirs is high, varies considerably and does not appear to follow the same changes that are noticed in the inorganic contents. It is lowest at the close of the wet season, increases slightly during the dry season, due to concentration affected by evaporation, and shows an increase at the beginning of the wet season due to the wash from the unwashed watersheds.

At the beginning of the rainy season the nitrites increase. This change is probably accounted for by the nitritification of the lower nitrogen compounds in the soil. The nitrites gradually decrease, and would tend to point to a reducing or denitrifying action in the reservoirs.

In the distillation for nitrogen as albuminoid of ammonia 8 tubes of 50 c. c. each are distilled off, and usually the eighth tube contains considerable ammonia. This would tend to show that the organic matter is in an undecomposed condition and is of a vegetable rather than animal origin.

The high organic content of the waters can not be looked upon as an index of pollution, because one is safe in assuming that they would be high on account of the luxuriant growth of vegetation on the watersheds.

The temperature of the waters is nearly a constant, and varies but slightly from the mean atmospheric temperature. Because of this constant temperature a condition very much like stagnation, which prevails during the late summer and winter months in reservoirs in temperate countries, occurs. The water near the bottom of the reservoirs has an offensive odor and its organic and inorganic content is usually higher than the water taken from near the surface.

It is the practice now to draw the supply from as near the surface as possible and the waste from the bottom gates. This practice will tend to keep the fresh water from going over the spillway, and will get rid of a large amount of water which has laid in a quiescent state near the bottom of the reservoir.

As soon as the dry season starts the mineral constituents increase and continue to increase until the close of the season. This increase is caused by the concentration brought about by evaporation. During the season very little water enters the reservoirs and the amount of surface wash is almost nothing. Sedimentation takes place rapidly and carries down to the lower strata many bacteria which are present during the wet season. The germ content of the reservoirs is comparatively low during the dry season, except when some local condition arises which causes an increase for a short time. The concentration of inorganic constituents continues throughout the dry season and reaches its greatest height at the close of that period. When the wet season starts the alkalinity and total solids begin to diminish very noticeably because of the dilution caused by the entrance of fresh water and the decrease continues until the water runs over the spillway. It is thought that by wasting through the bottom gates the mineral content of the waters can be still further reduced.

Rio Grande Reservoir.

Capacity	gallons..	496, 670, 000
Area of watershed	acres..	2, 015
Height of spillway above sea level	feet..	238

Rio Grande Reservoir is situated on the Pacific slope, about 10 miles northwest of the city of Panama, and has been in service for three years. The reservoir supplies the towns of Culebra, Rio Grande, Paraiso, Pedro Miguel, Miraflores, La Boca, Ancon, and Panama. The consumption from this reservoir is about two and one-half million gallons daily.

Rio Grande and Camacho are more nearly alike than either of the other two reservoirs because they are both practically on a continuation of the same watershed.

Camacho Reservoir.

Capacity	gallons..	296, 000, 000
Area of watershed	acres..	592
Height of spillway above sea level	feet..	365

Camacho Reservoir was put in service early in 1907 and is situated about 2 miles west of Empire. The reservoir supplies the towns of Empire, Las Cascadas, and Bas Obispo.

Carabali or Gorgona Reservoir.

Capacity	gallons..	80,000,000
Area of watershed	acres..	1,552
Height of spillway above sea level	feet..	75

Carabali Reservoir is situated about 1 mile west of Gorgona and supplies the town of Gorgona. It was put in service in the spring of 1906.

Brazos Brook Reservoir.

Capacity	gallons..	641,000,000
Area of watershed	acres..	640
Height of spillway above sea level	feet..	48.5

Brazos Brook Reservoir is situated about 2 miles northwest of Mount Hope and furnishes the towns of Mount Hope, Cristobal, and Colon with water. It was put in service July 1, 1906. The dam and spillway at Brazos Brook Reservoir was raised during the past year in order to secure several feet additional depth, which gave the reservoir an added capacity of about 215,000,000 gallons.

FILTRATION PLANTS.

The two filtration plants, one at Mount Hope and the other at Ancon, are identical in construction and consist of three New York sectional wash horizontal pressure filters of one-half million gallons capacity each. Alum is used as the coagulent, and the treated water passes to the filters. The time interval between the application of the alum and its entrance into the filters is less than a minute.

Rio Grande water being free from human pollution, a great reduction in germ content is not desired in filtering. Enough coagulent is used to arrest the suspended matter on the sand beds and remove a large per cent of the color, but in so doing a bacterial removal is also secured which will average from 70 to 80 per cent. During the dry season from three-quarters to one grain of alum per gallon is required to furnish a good affluent. When the wet season commences the raw water is more difficult to handle and requires nearly twice as much alum. This is due to the fine matter in suspension, both of organic and inorganic nature. During the dry season the filters are washed once a day and during the wet season at least twice a day.

The Ancon plant supplies water to the city of Panama and that section of Ancon on the high-pressure service.

At the Mount Hope plant the influent or raw water is supplied to the filters from the Brazos Brook Reservoir and because of the nature of this supply the operation of the filter plant has not been very successful.

Brazos Brook supply is high in suspended matter, organic, as shown by the differences in samples 38 and 38a, Table No. 1. This organic matter forms a gelatinous coating on the top of the sand beds when it has been treated with alum. This coating cuts down the pressure and it is necessary to wash the filters frequently. To secure a good effluent it is necessary to add from two and one-half to three grains of alum per gallon, but when this amount of coagulent is added the filters have to be washed so often that they are out of service nearly a third of each day.

Experimentally it has been found that this water can be cleared if the alum-treated water is allowed to remain in storage a few hours before introducing it into the filters.

A coagulation basin of 300,000 gallons capacity is being built and when completed will insure a storage of from three to four hours. This coagulation basin will be completed in a few months and a good effluent will then be secured.

The cities of Panama and Colon, Republic of Panama, are furnished with their water supply by the Isthmian Canal Commission, and to keep a record of the quality of the water furnished these two Panamanian cities, bacteriological samples have been taken from different taps in the two respective cities twice during the month since February of the present year.

TABLE 3.—*Bacterial contents of Panama and Colon water supplies.*

Sample No.	Date.	Source.	Cubic centimeters used.	Plate count.	Bacteria per cubic centimeter.	B. coli present in—	B. coli not present in—
	1908.						
1	Feb. 12	Panama No. 1	1.0	11	11	11.0	2.0
2	...do....	Panama No. 2	1.0	40	40	....	2.0
3	...do....	Panama No. 3	1.0	73	75	....	2.0
4	Feb. 13	Colon No. 1	1.0	120	120	....	2.0
5	...do....	Colon No. 2	1.0	125	125	....	2.0
6	Feb. 24	Panama No. 1	1.0	190	190	....	10.0
7	...do....	Panama No. 2	1.0	200	200—	....	10.0
8	...do....	Panama No. 3	1.0	90	90	....	10.0
9	Feb. 28	Colon No. 1	1.0	190	190	....	10.0
10	...do....	Colon No. 2	1.0	60	60	....	10.0
11	Mar. 12	Colon No. 1	.5	140	280—	....	10.0
12	...do....	Colon No. 2	.5	122	240	....	10.0
13	Mar. 20	Panama No. 1	.5	57	115	....	10.0
14	...do....	Panama No. 2	.5	73	145	....	10.0
15	...do....	Panama No. 3	.5	40	80	....	10.0
16	Mar. 25	Colon No. 1	.5	166	330	10.0	....
17	...do....	Colon No. 2	.5	40	40	....	10.0
18	Mar. 28	Panama No. 1	1.0	27	27	....	10.0
19	...do....	Panama No. 2	1.0	31	31	....	10.0
20	...do....	Panama No. 3	1.0	11	11	....	10.0
21	Apr. 6	Panama No. 1	1.0	130	130	1.0	....
22	...do....	Panama No. 2	1.0	110	110	....	10.0
23	...do....	Panama No. 3	1.0	310	310	....	10.0
24	Apr. 8	Colon No. 1	1.0	1,200	1,200	10.0	....
25	...do....	Colon No. 2	1.0	1,300	1,300	....	10.0
26	Apr. 22	Colon No. 1	.1	260	2,600	10.0	....
27	...do....	Colon No. 2	.1	280	2,800	....	10.0
28	Apr. 29	Panama No. 1	.5	170	340	10.0	....
29	...do....	Panama No. 2	.5	210	420	10.0	....
30	...do....	Panama No. 3	.5	140	280	....	10.0
31	May 7	Colon No. 1	.05	300	6,000	10.0	....
32	...do....	Colon No. 2	.05	350	7,000	10.0	....
33	May 15	Panama No. 1	.2	27	135	....	10.0
34	...do....	Panama No. 2	.2	5	25	....	10.0
35	...do....	Panama No. 3	.2	38	180	....	10.0
36	May 21	Colon No. 1	.1	70	700	.5	....
37	...do....	Colon No. 2	.1	150	1,500	1.0	....
38	May 25	Panama No. 1	.5	95	190	10.0	....
39	...do....	Panama No. 2	.5	110	220	1.0	....
40	...do....	Panama No. 3	.5	125	250	1.0	....
41	June 4	Colon No. 1	.1	240	2,400	.1	....
42	...do....	Colon No. 2	.1	210	2,100	.5	....
43	June 9	Panama No. 1	.5	200	400	1.0	....
44	...do....	Panama No. 2	.5	250	500	1.0	....
45	...do....	Panama No. 3	.5	100	200	1.0	....
46	June 18	Colon No. 1	.05	190	3,800	1.0	....
47	...do....	Colon No. 2	.05	180	3,600	1.0	....
48	June 22	Panama No. 1	.1	60	600	10.0	....
49	...do....	Panama No. 2	.1	41	410	10.0	....
50	...do....	Panama No. 3	.1	95	950	10.0	....

The supply furnished Panama is filtered and of good quality; that furnished Colon is high in color and bacterial content at certain times but these objections will be done away with when the Mount Hope filtration plant is put into operation.

TABLE 4.—*Mineral analysis of water supplies.*

[Parts per million.]

Sample No.	Date.	Source.	Silica.	Calcium oxide.	Magnesium oxide.	Iron and aluminum oxide.	Sulphates.	Alkalinity.	Chlorine.	Free carbon dioxide.	Nitrites.	Nitrates.	Total solids.
	1908.												
1	Feb. 5	Rio Grande Reservoir.	31.1	16.0	1.7	1.9	3.5	66.0	3.5	2.0	Trace.	None.	110
2	Feb. 4	Camacho Reservoir.	30.8	22.0	1.8	1.6	.3	68.0	3.5	2.0	Trace.	None.	129
3	...do....	Gorgona Reservoir.	39.9	27.8	1.1	5.0	None.	88.0	5.0	3.0	Trace	None.	179
4	...do....	Chagres River	28.7	16.3	.8	2.7	None.	60.0	7.0	5.0	Trace	Trace.	116
5	...do....	Gatuncillo River	34.5	25.6	.8	2.7	None.	87.0	6.0	5.0	Trace.	Trace.	135
6	...do....	Brazos Brook Reservoir.	13.5	10.1	.4	3.9	3.0	32.0	5.0	3.0	Trace.	Trace.	84

Incrustants were determined by the soda reagent method, and more twentieth normal sulphuric acid was required to back titrate than there was soda reagent added. The excess amount of acid required was small, and the results would indicate a small amount of alkaline carbonates.

Trouble from algæ growth has only occurred a few times during the past year. Gorgona Reservoir was treated twice for a growth of anabæna, and Brazos Brook Reservoir was treated once for microcystis.

The reservoir water being fairly clear and of a favorable temperature for the growth of microorganisms, trouble from this source can be expected at any time. The water supplies should be examined at frequent intervals to prevent trouble from algæ growth.

Last September considerable trouble was caused by odors in the Rio Grande and Brazos Brook supplies, and the odors were not due to algæ growth. The trouble was due to the decomposition of organic matter and was remedied by areating the supplies. The Rio Grande supply was areated by running an air line to the bottom of the gatehouse and allowing the air to rise through the column of water. Some air was carried into the main, but most of it escaped at the gatehouse. A decided odor was noticeable at the gatehouse when the air supply was turned on. The Brazos Brook supply was areated by introducing air into the pump suction at Mount Hope.

No epidemics have occurred during the past year that have been caused by polluted water, and the sanitary condition of the supplies examined is good. The high germ content of the reservoirs at certain periods is not caused by human pollution, and the *B. coli* undoubtedly owe their presence to the fact that the watersheds are inhabited by wild animals.

PLATE 45.

GORGONA RESERVOIR.

CONSTRUCTING THE ROAD FROM MOUNT HOPE TO GATUN.

PLATE 47.

COLON—MOUNT HOPE ROAD BEFORE CONSTRUCTION.

PLATE 48.

COLON—MOUNT HOPE ROAD AFTER CONSTRUCTION.

PLATE 49.

BOLIVAR STREET, COLON, BEFORE PAVING, JANUARY, 1908.

PLATE 50.

BOLIVAR STREET, COLON, AFTER PAVING, JUNE, 1908.

PLATE 81.

TENTH STREET, COLON, BEFORE PAVING.

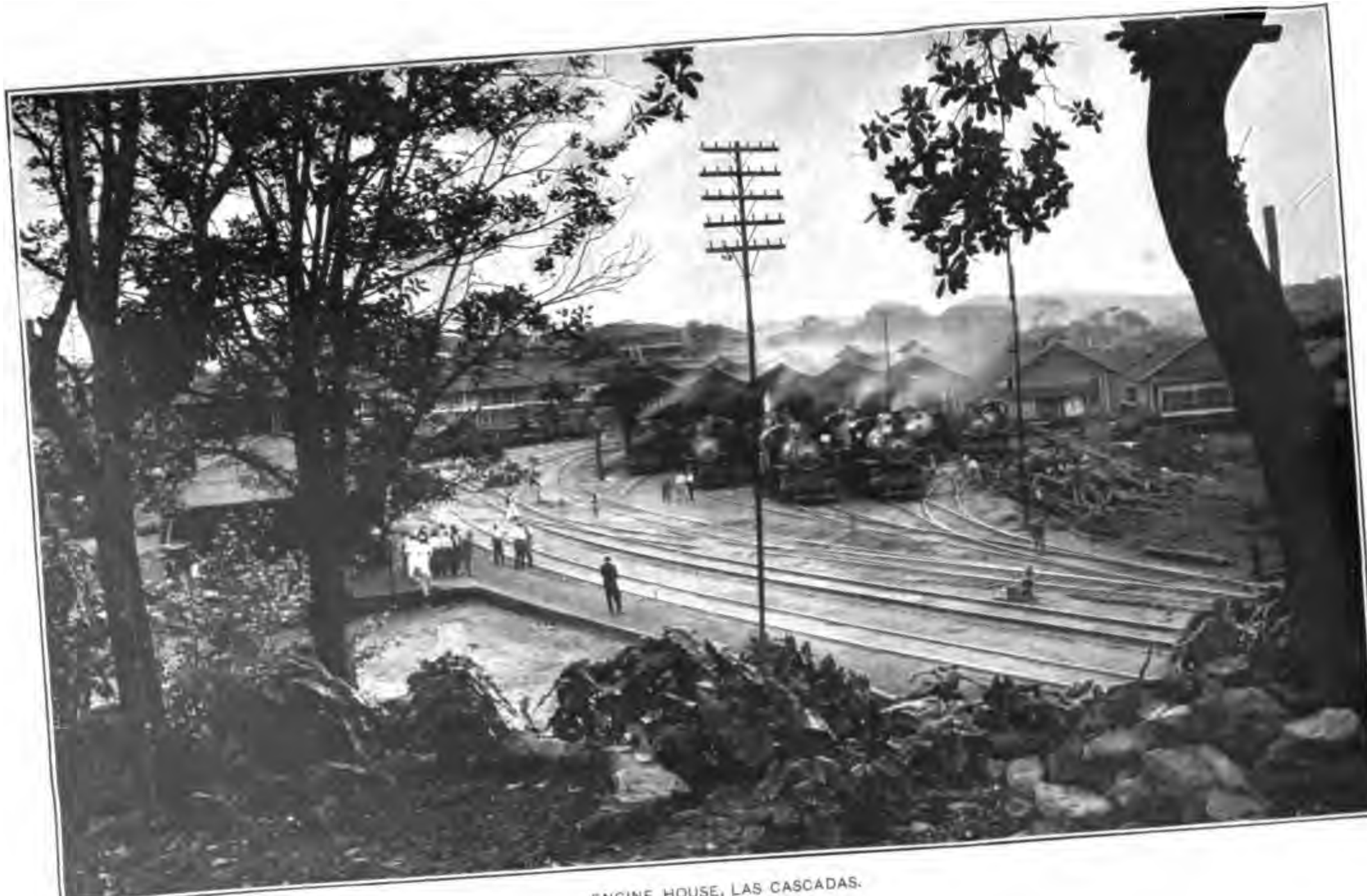
Plate 52.

TENTH STREET, COLON, AFTER PAVING.

PLATE 53.

COAL CHUTE, PEDRO MIGUEL YARDS.

PLATE 54.



ENGINE HOUSE, LAS CASCADAS.

APPENDIX D.

REPORT OF MAJ. CHESTER HARDING, CORPS OF ENGINEERS, U. S. ARMY, ASSISTANT DIVISION ENGINEER, ON FOUNDATIONS OF GATUN LOCKS.

GATUN, CANAL ZONE, *July 23, 1908.*

COLONEL: In compliance with instructions contained in your letter of the 3d instant, I have the honor to submit herewith a report with seven drawings (Plates 55 to 61) explaining the examinations of the materials on which the Gatun Locks are to be founded, and also the examinations made for the presence of water below the foundations.

MATERIALS IN THE LOCK FOUNDATIONS.

Before my connection with this work, Major Sibert had directed that the borings made prior to May, 1907, be supplemented by additional borings made with diamond drills and extending well below the bottom of the lock walls. The investigations thus instituted have been continued throughout the past fiscal year along lines directed from time to time by Major Sibert, with the result that the character of materials on which the locks are to be built is as thoroughly known as it is possible to know it until the excavation has exposed the entire foundation bed on which the concrete is to be laid. The data obtained have been carefully recorded, and the samples of materials have been preserved and so marked as to indicate in each case the hole and the depth below the surface from which the samples were taken. From these data I have been able to prepare the accompanying drawing (Plate 55) showing not only the character of the material on which each wall is to rest, but also the material underlying the walls to depths of 50 feet or more.

The excavation in the upper pair of locks has, at the present writing, reached a depth of 9 feet above sea level in the lower portions, the strata marked "conglomerate" and "soft sandstone" having been cut into and exposed. Wherever this has been done, the indications of the drill records have been amply verified, and it may be confidently expected that the same will hold true throughout. From the nature of the diamond drill, samples of hard materials are as a general rule brought up in their natural condition, and an examination of the samples gives an accurate idea of the material as it exists in place. In certain cases of the conglomerate, which is composed of pebbles or other hard aggregates, held together by a cementing material, it was not practicable to get samples in this way, as the pebbles became detached from the mass by the twisting motion and disintegrated the material under the drill. In such cases, where the conglomerate was subsequently exposed by the steam shovels, the material in place was found to be a conglomerate rock sufficiently hard to require blasting before it could be removed.

I would invite especial attention to the layer of material marked "soft sandstone" on the drawing. It will be observed that this material immediately underlies the conglomerate throughout the entire length of the locks and rises sufficiently near the surface in the upper locks to form the foundations of the walls for a portion of their lengths. The first indications of the diamond drills led to the belief that this material might be sand without any cementing element. Although sand is an excellent foundation material when confined, the fact that this stratum was found to be water bearing (which will be referred to later in this report) gave rise to some anxiety lest it would be necessary to remove the entire stratum from the upper locks and found the walls upon the stone underneath. To investigate the matter, a pit, 6 by 8 feet in horizontal dimensions, was dug in close proximity to the lock site, extending down and into the material in question. The material was found to possess sufficient coherence to be difficult to remove by a pick, and blasting was resorted to, to facilitate the excavation. When the soft sandstone was exposed in the pit, a test of its bearing capacity was made. An actual load of 530 pounds per square inch, applied over a surface of 6 inches square, produced a total settlement of 0.029 foot. Following is a copy of my report of this test, addressed to Major Sibert:

FEBRUARY 27, 1908.

Referring to my report of the 17th instant, concerning a test of the bearing capacity of the soft sandstone in test pit No. 7, I have the honor to inclose herewith a supplementary report showing the additional settlement after the platform had been readjusted into a level position. The additional settlement recorded from 10.45 a. m. on February 17 to 7 a. m. on February 19 is 0.005 foot; the entire settlement from the beginning of the test on February 14 being 0.029 foot.

Immediately after the reading on the morning of the 19th instant, the load was removed and the excavation continued. The particular part of the bottom of the pit on which the test load rested was brought out practically intact in a block about 2 feet square and 8 inches deep, and is now in this office available for inspection. The indentation of the plate 6 inches square, through which the load on the plate was transmitted, is clearly marked. From the character of the material at the bottom of this indentation I am convinced that the settlement was due to the erosion of the material by the water which percolated through it constantly during the test, rather than the compression of the material.

The result of this test justifies the statement that it will be unnecessary to remove the soft sandstone, and that the lock walls may be safely founded upon it if proper precautions are taken to prevent erosion. When the lock excavation is completed, such further tests of bearing capacity as may be deemed necessary may be made of the foundation bed itself.

Under the soft sandstone the material changes to an argillaceous stone similar to the stratum nearest the surface, but having mixed with it in varying quantities a volcanic material designated as tufa. This tufa is porous and light in weight, and when unmixed with the heavier stone will require the same precautions against scour as will the soft sandstone. The mixture becomes denser as the proportion of tufa is less. Owing to the lack of uniformity in the distribution of tufa, it is impossible to give a general description of the material underlying the soft sandstone, and a thorough understanding of the character of the material as it occurs in any particular drill hole can be obtained only by an examination of the samples. Where the holes have actually penetrated some distance into the material in which the tufa is absent altogether, it has been possible to draw a

line below which the material may be designated as argillaceous sandstone without any qualification. After a careful study of the samples, I would describe the materials involving tufa developed in certain holes as follows (the elevations noted refer to sea level):

Hole No. 631: Between elevations +25.7 and −24.3 there is a varying amount of tufa mixed with argillaceous sandstone. Below −24.3 the material becomes a typical blue argillaceous sandstone.

Hole No. 632: From +5.8 to −42 the material has rather less tufa than in hole 631, but throughout the distance between +5.8 and −42 there are occasional samples of material in which the tufa largely predominates. The proportion of tufa does not obey any regular law with reference to depth. Below elevation −42 the material changes to a typical blue argillaceous sandstone.

Hole No. 721: From +4.4 to −37 occurs a mixture of argillaceous sandstone and tufa, with argillaceous sandstone predominating below −23. Below −37 there are only small traces of tufa, and the typical blue argillaceous sandstone is reached at −57.6.

Hole No. 634: From −34 to −51 the samples all show some tufa mixed with a high percentage of argillaceous sandstone. Below −51 the tufa disappears except for occasional traces.

Hole No. 637: From −57 to −89 occurs a mixture of tufa and argillaceous sandstone, with the tufa predominating down to −77 and with the argillaceous sandstone predominating without much variation to −89. Below −89, except for occasional traces, the tufa disappears.

Hole No. 684: From −60 to −88.5 there is practically a uniform run of a mixture of tufa and argillaceous sandstone, with the tufa predominating. Below −88.5 the tufa continues gradually to diminish in quantity until the argillaceous sandstone predominates at about −93, and the tufa continues to diminish to −98, where it practically disappears, and no soft material is encountered to the bottom of the hole at −149.1.

Hole No. 722: From +9.7 to −31.3 a mixture of tufa and argillaceous sandstone occurs, the argillaceous sandstone predominating. Below this elevation no tufa occurs, and argillaceous sandstone continues.

Hole No. 630: From +9 to −6 there is a varying amount of tufa mixed with argillaceous sandstone. Below −6 the material becomes a typical blue argillaceous sandstone.

Hole No. 629: Between elevations +30.5 and +4 the samples indicate a stratification of pure tufa and argillaceous sandstone alternating with each other. Between elevations +4 and −10 the stratification disappears and the material is a mixture of argillaceous sandstone and tufa, with the argillaceous sandstone largely predominating. Below −10 the tufa disappears.

Hole No. 358A: From elevation −10 to −15 the material is a mixture of tufa and argillaceous sandstone, the tufa being in excess. From −15 to −40, there is more of the argillaceous sandstone, and at −40 the tufa practically disappears.

Hole No. 635: From elevation −33 to bottom of hole at −70 the material is quite uniform, being a mixture of argillaceous sandstone and tufa, the argillaceous sandstone being in large proportion.

Hole No. 438A: From elevation 3 to −15 the material is nearly

all argillaceous sandstone, with occasional samples of almost pure tufa. Below −15 there are only occasional traces of tufa.

Hole No. 627: The conditions in this hole are the same as in hole No. 438A.

Hole No. 633: From elevation −2.5 to −19 the material is a uniform mixture of tufa and argillaceous sandstone, the sandstone being in excess. Below −19 the quantity of tufa gradually diminishes to elevation −31, where it disappears except for occasional traces at intervals to −50.

Hole No. 636: From elevation −37, where the tufa is mixed with argillaceous sandstone in about equal proportions, the tufa gradually diminishes to the bottom of the hole at −70, where the argillaceous sandstone is largely in excess.

Hole No. 583: From elevation −40 to −74 there is some tufa mixed in small proportions with argillaceous sandstone. Below elevation −74 the tufa practically disappears.

Hole No. 638: From elevation −45 to bottom of hole at −80 there is a uniform mixture of tufa with argillaceous sandstone, the argillaceous sandstone predominating.

Referring finally to Plate 55, it will be seen that the materials on which the walls and floors of the three pairs of locks will rest are as follows:

The lower locks, to be excavated down to elevation 55.67 below sea level, will be founded upon argillaceous sandstone, a dense material which has been exposed generally throughout the lock site by excavations thus far made. The middle locks will rest upon argillaceous sandstone in part, and in part on the underlying conglomerate, which conglomerate has also been exposed and its bearing capacity tested. The upper locks will rest in part on argillaceous sandstone, in part on conglomerate, and in part upon a stratum of soft sandstone. There is no doubt of the ability of these different materials to bear the greatest load that will be transmitted to them by the lock walls, and the locks may be safely founded upon them if means are taken to exclude the underground flow of water from the softer materials on which some of the walls will rest.

EXAMINATIONS FOR WATER UNDER FOUNDATIONS.

During the progress of the borings it developed that ground water is present under considerable pressure in some of the conglomerate and in the soft sandstone generally. This fact led to a systematic investigation of the matter, with results indicating an underground flow of water through the soft sandstone. Daily readings of the height of water were taken in all the available drill holes in the lock site, and important information was obtained from the pit referred to in the first part of this report. Plate 56 herewith shows the location of all the holes that give information of interest in this connection. The elevation, in feet and tenths, above sea level to which the water rose in each hole is marked in figures on the map in each case. It should be explained that as a general rule no appreciable ground water was found until the holes pierced the conglomerate, and that full pressure was not developed until the hole reached the layer of soft sandstone. The elevations of the water given therefore measure the water pressure existing in the water-bearing material.

From these data the inference may be fairly drawn, in my judgment, that the source of the underground flow is remote from and considerably higher than the ground upon which the lock site is situated. I would also infer that the water approaches the lock site from the southeast and that the flow under the lock site is toward the sea, about parallel with the axis of the locks. Plate 57, showing lines drawn through points of equal water pressure, clearly indicates this probability.

In the test pit ground water was encountered in the conglomerate at elevation 7.5 above sea level and continued to come in freely through the sides and bottom below that elevation as the pit was excavated. Constant pumping was necessary to keep the water down in the pit, and an average of 41,530 gallons per twenty-four hours was removed. The effect of this pumping upon the elevation of water in the holes throughout the lock site was very marked, and may be readily inferred by comparing Plate 57, which shows lines of equal water pressure just before the pumping was begun, with Plates 58, 59, and 60, showing similar lines at different dates thereafter. The pumping was stopped on March 13, 1908, and three days thereafter the water had risen to level + 16.6 in the pit and to the elevations shown on Plate 61 in the various drill holes. The volume of flow under the lock site is therefore small enough under present conditions to have been appreciably diverted by the drainage into a sump 6 by 8 feet in horizontal dimensions.

Very respectfully,

CHESTER HARDING,
Assistant Division Engineer.

Lieut. Col. GEO. W. GOETHALS, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.
(Through Maj. Wm. L. Sibert, U. S. Army, division engineer.)

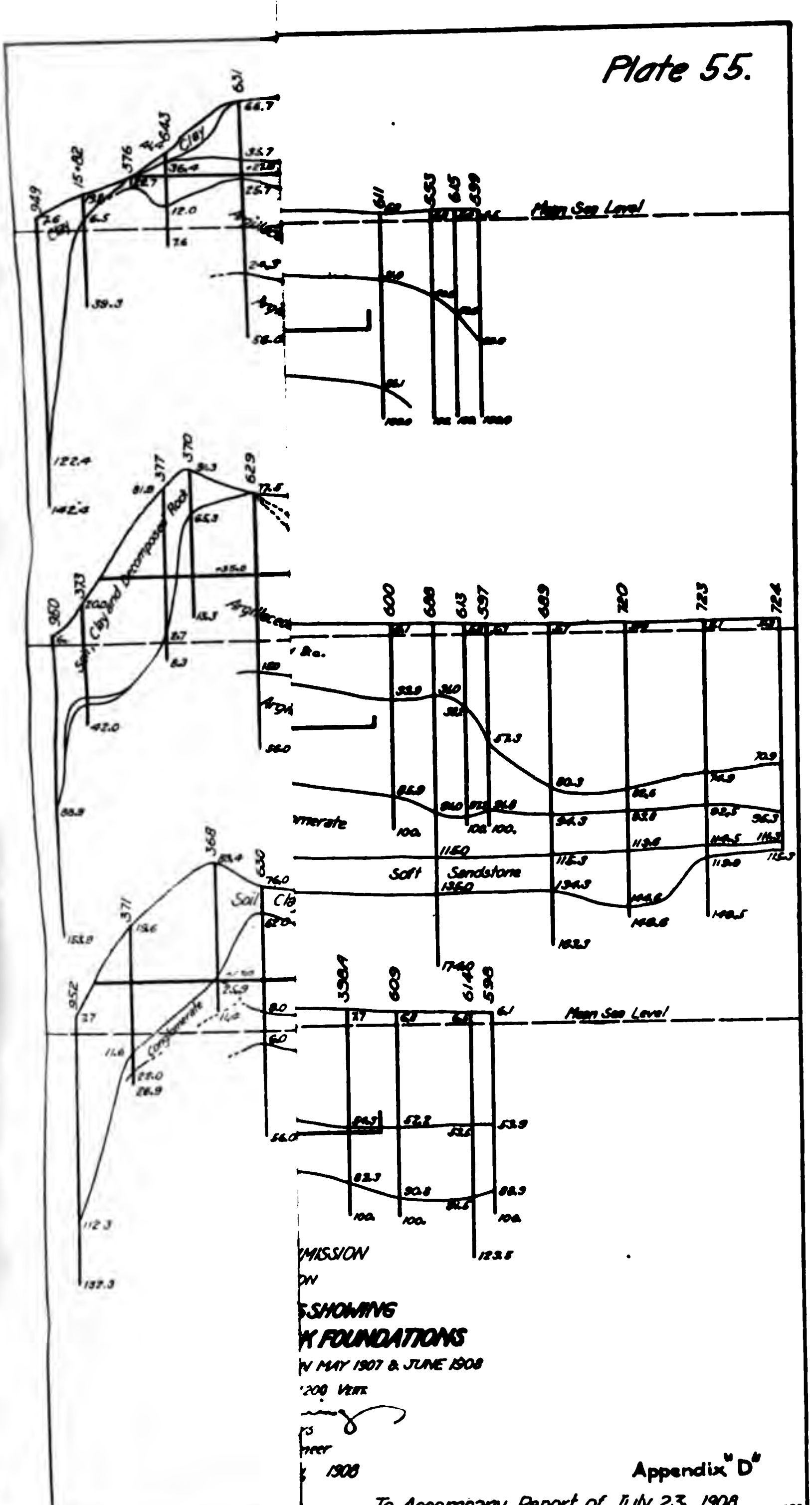


Plate 55.
Mean Sea Level
Clay
Soil
Clay and Decomposed Rock
Conglomerate
Soft Sandstone
MISSION
SHOWING
K FOUNDATIONS
N MAY 1907 & JUNE 1908
Appendix "D"
To Accompany Report of July 23, 1908

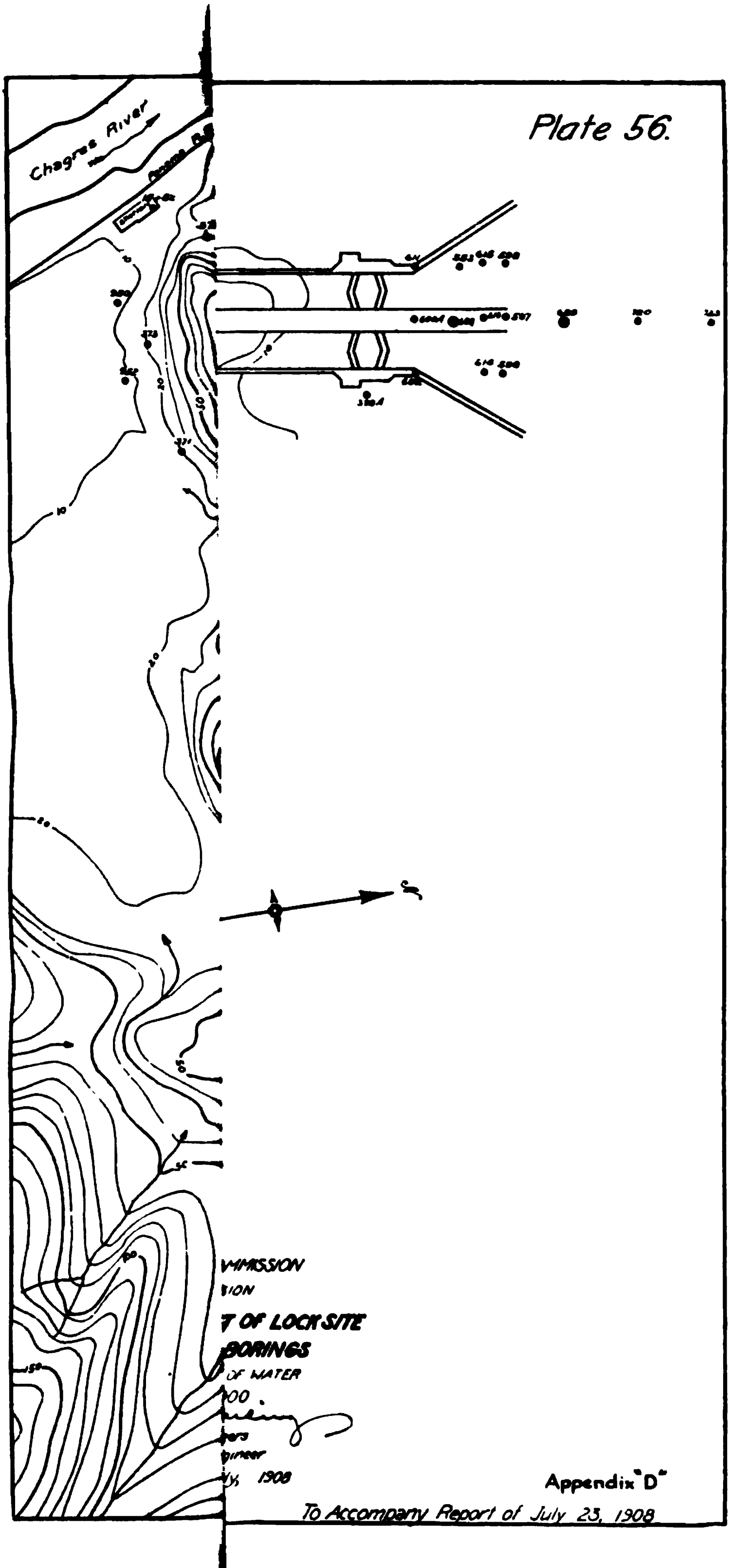


Plate 56.
Chagres River
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BORINGS
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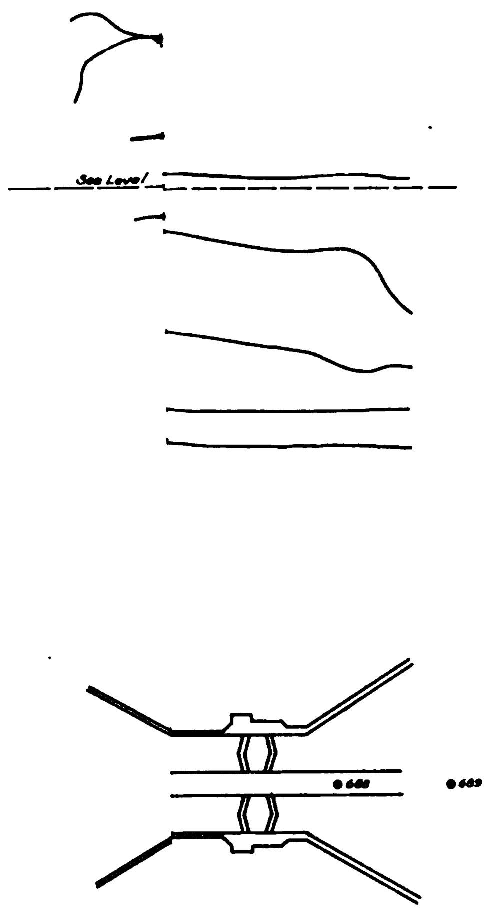
Appendix "D"
To Accompany Report of July 23, 1908

Plate 57.



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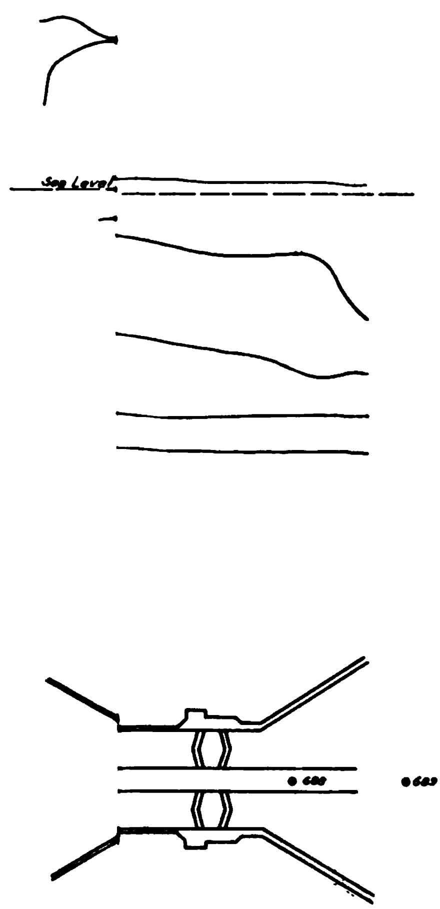
Appendix "D"

To Accompany Report of July 23, 1908

Plate 58.



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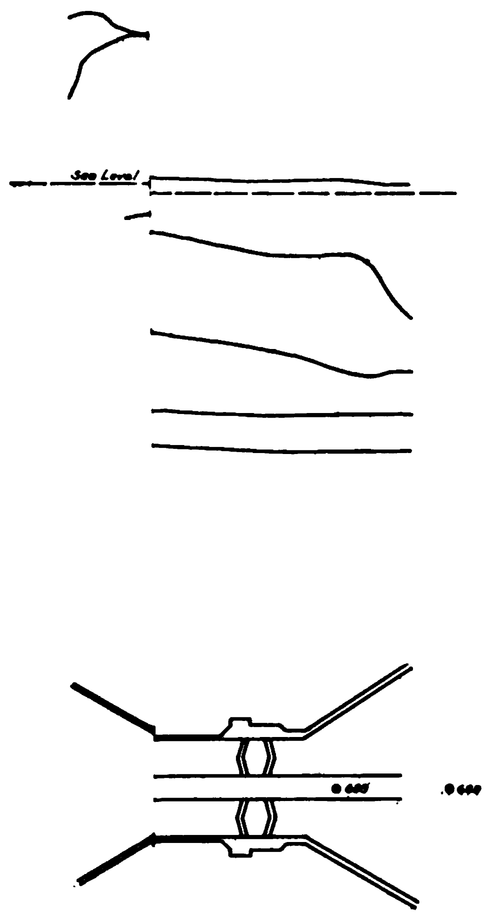
Appendix "D"

To Accompany Report of July 23, 1908

Plate 59.



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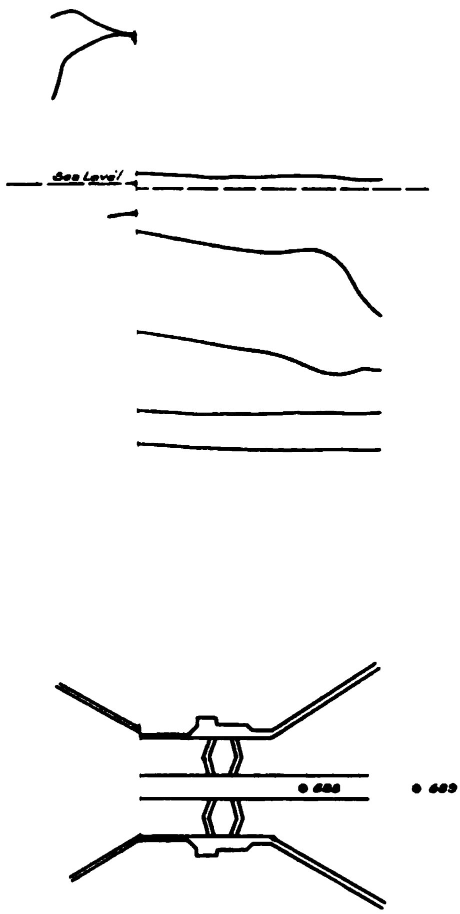
Appendix "D"

to Accompany Report of July 23, 1908

Plate 60.



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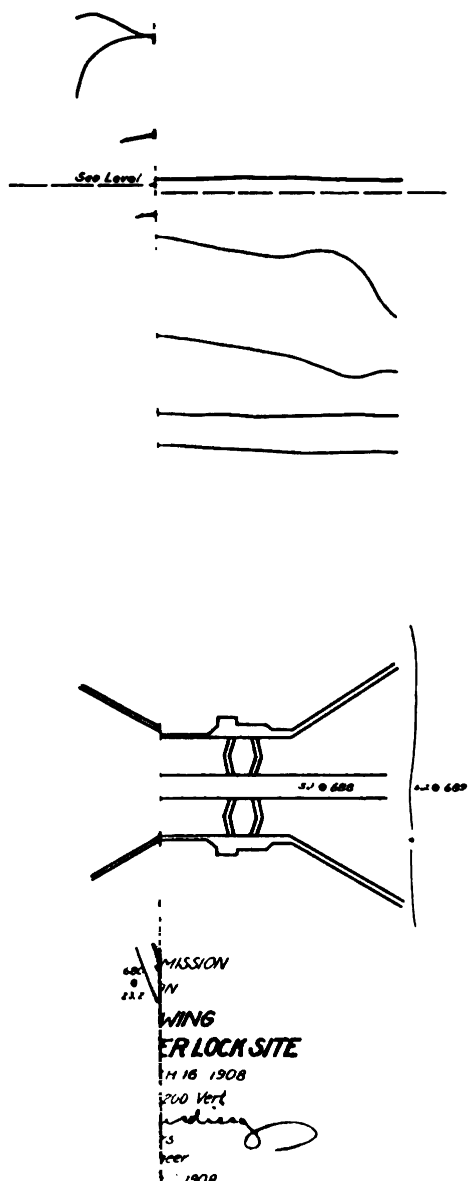
Appendix "D"

To Accompany Report of July 23, 1908

Plate 61.



Appendix "D"

To Accompany Report of July 23, 1908

APPENDIX E.

REPORT OF C. M. SAVILLE, ASSISTANT ENGINEER, ON GATUN DAM INVESTIGATIONS.

GATUN, CANAL ZONE, *August 29, 1908.*

COLONEL: I have the honor to transmit herewith a report on the materials and foundations for the proposed dam at Gatun.

The investigations at Gatun were begun about December 1, 1907, and their sequence and character are given below.

The first work undertaken was for the purpose of locating a sufficient quantity of material suitable for a dam which was to be built by the sluicing process. Material which seemed to be suitable for this work has been located down the Chagres River valley north of the proposed dam, and also to the south of the dam in the Gatuncillo River valley. Besides the above, the records of previous preliminary borings indicate a quantity of material that may be suitable in the valley of the Chagres also south of the dam. All these areas are within 1½ miles of the dam in locations suitable for hydraulic dredging. The total quantity available is apparently not less than 20,000,000 cubic yards, based on excavation not lower than 50 feet below sea level. If it should appear that sufficient material is not available in these localities, an additional amount could be obtained from the excavation in Limon Bay.

The next work undertaken was the investigation of foundations for the dam and spillway. Much work on these lines had previously been done, and at first it was intended merely to verify and interpret that which had gone before. As the work advanced, however, some new questions arose, and by order of the chief engineer careful and systematic investigations of the valley and its rock bottom were undertaken. It was especially directed that careful search should be made to show whether there were any permeable connections through the alluvial deposits in the comparatively narrow gorges across which the dam will be built between the extensive swamp areas to the north and the broad flats of the Gatuncillo and Chagres to the south. Besides this, it was directed that the alluvial deposits in the gorges and the rocks underlying them and outcropping in the hills should be carefully studied to determine their ability to support the proposed structure and to resist the flow of water through them. The conclusions arrived at on these matters are:

1. The rocks themselves, even those portions which are soft and readily yield to excavation methods, are of sufficient strength to support any loads that may come on them in the proposed construction.

2. Some of the rocks are of open texture and permit the flow of water, the readiness with which this flow is allowed depending mostly on the condition of the rock and its resistance to the disintegrating action of surface conditions.

The principal water-bearing medium seems to be the joints and seams which cut through the various strata and allow the passage of

large quantities of water. The occurrence of water-bearing joint planes in great part, and to a lesser degree the presence of a layer of disintegrated conglomerate of coarse sandstone at the southerly entrance of the spillway, will undoubtedly require the construction of a masonry cut-off wall in the hill at this point. This work, however, presents no serious difficulty and only such engineering construction as is ordinarily encountered in dam building. The excavation for this wall will be in comparatively compact rock, which will excavate easily but will not require complicated bracing, if any at all is necessary. A comparatively impervious layer for the footing of the wall will be found at no excessive depth.

The alluvial deposits in the gorges of the Chagres River, across which the dam will be built, are composed almost wholly of a very fine sand with a large proportion of clay from the surface down for a considerable distance, the maximum depth at one point being about 80 feet. Underlying this for a distance of 100 feet or more is a thick deposit of blue clay containing little sand and some shells. Beneath this, and directly overlying the rock, is a deposit varying in thickness up to 20 feet, and containing small bowlders and angular gravels and sands thoroughly consolidated and cemented together with finely divided clays and silts. This breccia resembles somewhat the "hard pan," a "glacial till" of the northern countries. It is apparently the product of the decomposition of the immediate rock surface. Of itself it is waterproof and nonwaterbearing, having been made so by the leaching and filling from the overlying deposits. When exposed to any powerful washing action, however, the material breaks down, the clay is dissolved and washed out, and the resulting sample has all the characteristics of a coarse gravel or sand that might be freely water bearing. That this is not the case is shown by numerous borings and samples. The artesian flows encountered in this material are probably local in their occurrence and due to the action of water which takes its pressure from the near-by hills. This water, however, is shut in by the impervious conditions of the material as a whole, and thus pent up it indicates a greater head than would be the case if it had free discharge.

3. The borings and excavation show no continuous layer of loose sand or gravel. No deposit has been encountered that appears sufficiently extensive and permeable to endanger the proposed structure when it is performing the functions for which it is designed.

Although this is the case, on account of the composition of the upper layer and the fact that it does allow some water to pass through it even at a very slow rate, it probably will be deemed advisable to drive a cut-off wall of sheet-piling through this material and across the valley. This will afford additional resistance and effectively prevent percolation. The above-ground conditions of construction can be watched and precautions taken. The underground conditions of foundation are determined only by deduction, and it is therefore the part of wisdom to err, if at all, on the side of conservatism.

The experiments with a model dam have demonstrated the feasibility of construction by pumping methods.

The materials selected and taken from the locality previously determined upon have demonstrated their suitability to make a stable and satisfactory structure.

The packing and consolidation of the materials as laid down by the hydraulic process present so impermeable a structure that the resultant leakage can be considered negligible. The maximum rate under conditions that probably never can obtain in the actual dam was less than one-half gill per minute per horizontal linear foot of dam. If the proposed dam were similarly impervious and subject to similar conditions, the seepage per linear foot would be about two quarts in three minutes in the maximum section.

The results thus far obtained are from a type of dam laid down by the hydraulic process and allowing the material deposited at the downstream slope to grade itself from coarse to fine on the water slope. In this form of construction practical conditions forbid the retention of the finer particles which tend to make the embankment the more impervious. On this account it is felt that the method usually employed in hydraulic-dam construction, i. e., depositing the materials on both faces and allowing them to flow toward the center of the dam, will be the most feasible in this case. This method will present a more stable upstream slope; it will be cheaper to build, as much more of the material pumped can be saved; and it will offer a much denser stop for the water, and thus undoubtedly reduce even the small amount of percolation that was obtained by the other method in the experimental dam.

The results of the investigations and experiments undertaken at Gatun show:

1. That suitable material is available and near at hand for the construction of the Gatun dam by hydraulic process.

2. That the foundations are suitable for such a structure as the proposed Gutun dam if they are properly treated.

3. That it is practically possible to construct a stable and watertight earth dam at Gatun of the materials available.

4. That the hydraulic method of construction, as proposed for this work, is feasible if proper conditions are observed.

The foregoing conclusions are based on data which are set forth in detail in what follows, and in the preparation of the report acknowledgment is due to the United States Geological Survey for quotations, tables, and diagrams taken from the publications of that department; to the Geological Survey of New Jersey for similar matter; to the United States Department of Agriculture for soil analyses; and to the Engineering News and Engineering Record.

MATERIALS FOR DAM CONSTRUCTION.

In searching for materials for hydraulic-dam construction the principal features considered were:

(*a*) Suitability of the material, both for hydraulic dredging and stability in the dam when deposited. For this purpose a sandy clay was sought which should have a sufficient percentage of sand to drain and compact readily and yet as much clay as possible to make for impermeability.

(*b*) Proximity of the material to the site of the proposed dam.

(*c*) Quantity of material available for the purposes of dam building.

Explorations and investigations established the fact that there were no local deposits at proper elevation or of sufficient extent to consider sluicing the material into the embankment. Hydraulic dredging of

the materials therefore seemed to be the only feasible method of construction. Suitable and available materials were found in two localities—south of the proposed dam in the Gatuncillo Valley, and north of the dam near the junction of the West Diversion and the Chagres River. Besides these, two other deposits can undoubtedly furnish material—south of the dam in the Chagres Valley toward the Trinidad mouth, and from the dredging in Limon Bay near the mouth of the Mindi River. The first two of these deposits have been explored by wash-boring methods; the location of the bore holes is shown on Plate 86 (1:10,000 topographical map of Gatun and vicinity) and the record of the holes on Plates 87 and 88.

As the materials from down the Chagres are similar in structure to those in the Gatuncillo River Valley but of much greater extent, the description of the latter is given in detail. It is expected, however, that the relative properties in the materials south of the dam, both in the Gatuncillo and Chagres, do not differ appreciably from those given below. The material from Limon Bay approximates the "medium sand" of the analyses, but contain a somewhat larger percentage of clay. While this material is the farthest away, it may seem advisable to use it in connection with the "brown and dark clay" deposits. These deposits are of much greater extent than here listed, but, because of their smaller percentage of sand, were not explored to greater distances from the dam. Although the Limon Bay deposits are comparatively some distance away (3 or 4 miles), yet there is the advantage that their transportation would increase the cost very little on account of the necessity now of transporting them to sea. This source, however, has been very little investigated, because it was felt that suitable materials were nearer at hand. Table 1 (below) shows the approximate quantities available:

TABLE 1.

	Cubic yards.
1. Deposits in Chagres River Valley, north	25,000,000
2. Deposits in Gatuncillo River Valley, south	5,000,000
3. Deposits in Chagres River Valley, south (say)	3,000,000
	33,000,000

Based on the indications of the amount of material pumped and saved in experimental dams (say, 60 per cent), there results from these sources an available amount of material for dam construction of about 20,000,000 cubic yards. If this amount should prove insufficient, there remains the Limon Bay deposits of sand which can advantageously be mixed with the brown and dark clay deposits in the vicinity of the dam which are not listed in this report. Down the Chagres these materials are located on both sides of the river, and extend from one-half mile to 1½ miles north of the dam site. The surface is level, and has an approximate elevation of plus 10. In estimating the quantities available, 50 feet was used as the limit of the depth from which the materials could be pumped.

Four or five samples of each material were analyzed, and the average effective size, uniformity coefficient, and per cent of clay and silt determined. By Hazen's formula, the approximate permeability of each may be ascertained. The analyses were made from wash samples, and therefore will approximate the condition of the materials after being deposited in the dam.

The larger percentage of the materials classified as "brown clay" and "dark clay" is clay and silt, but they contain enough sand so that, while very soft when deposited, they would probably become very compact if properly drained, and the stability and efficiency of the dam would not probably be impaired if it were necessary to use them, even in their natural condition.

The results of the analyses and the amounts of the various materials available follow in Table 2:

TABLE 2.

Material.	Available.	Average effective size.	Average uniformity coefficient.	Average clay and silt.
	Cubic yards.			*Per cent.*
Brown clay	4,000,000	0.0103	4.97	66.66
Dark clay	10,200,000	.011	7.25	56.7
Blue sandy clay	5,900,000	.015	5.0	55.9
Brown sandy clay	4,420,000	.022	6.7	29.4
Medium sand	480,000	.300	2.6	4.0
Total	25,000,000			

On Plate 86 (large map) is shown the location of the sand deposits: (1) Deposits on the Chagres River north of dam; (2) deposits on the Gatuncillo south of dam; (3) supposed deposits on Chagres River south of dam; (4) Limon Bay deposits, not shown on map, but available by pumping or transportation in barges up the French Canal.

In order that the stability of the dam may not be endangered by the excavation northerly for the purpose of obtaining construction material, it should not come nearer the extreme downstream toe than 1,500 or 2,000 feet. If a gradual inclined slope is given to this excavation, then will the condition be somewhat similar to a berm on the downstream slope of a high dam.

The following table (No. 3) shows typical mechanical analyses of the materials:

TABLE 3.—*Classification of samples of sand and clay.*

Hole No.	Elevation.	Classification—per cent by weight.							
		Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt and clay.	Effective sign.	Uniformity coefficient.
								Mm.	
800	− 2.8 to −16.8 feet	....	....	2.8	13.2	17.6	66.4	0.009	4.4
801	−27 to −42 feet	11.6	70.4	9.4	2.4	2.2	4.0	.30	2.6
	+13 to − 4 feet	....	1.8	14.2	38.4	11.4	34.2	.019	5.9
803	− 5.6 to −55.6 feet	....	1.2	2.8	7.2	12.8	76.0	.008	4.4
804	+ 2.4 to −12.6 feet	....	....	0.6	8.2	8.4	82.8	.008	4.0
810	−31.8 to −41.8 feet	....	6.8	27.4	36.6	8.4	20.8	.029	7.2
813	− 3.4 to −28.4 feet	....	6.2	6.8	27.8	17.2	42.0	.017	5.8
816	+ 6.1 to −13.9 feet	....	0.8	4.4	22.2	18.8	53.8	.01	5.1
817	+ 7.9 to − 2.1 feet	....	3.2	27.2	27.8	10.2	31.6	.02	8.5
818	− 5.3 to −35.3 feet	....	12.2	15.8	14.2	10.2	47.6	.013	9.4
819	+ 5.5 to −26.5 feet	....	5.2	20.8	36.2	8.8	29.0	.022	7.4
831	+11.2 to − 3.8 feet	....	2.6	4.4	22.2	8.4	62.4	.009	4.7
834	+12.5 to − 7.5 feet	3.0	3.4	23.8	35.4	7.2	27.2	.025	7.3
	− 7.5 to −57.5 feet	....	....	2.4	25.8	20.6	51.2	.01	6.2
843	+ 6.9 to −13.1 feet	....	1.4	2.8	9.6	10.2	76.0	.008	4.2
845	−14.9 to −84.9 feet	1.2	17.2	20.8	7.8	4.8	48.2	.016	13.1
847	+ 9.4 to −15.6 feet	....	....	5.0	9.2	11.2	74.6	.008	4.2
863	+ 9.1 to −10.9 feet	....	5.0	14.8	45.4	7.6	27.2	.022	6.3
864	+ 2.7 to −14.3 feet	....	....	....	....	8.4	91.6	.009	3.3

TABLE 3.—*Classification of samples of sand and clay*—Continued.

Sample No.	Color.		Location.	Character.	Classification—per cent by weight.						
	Wet.	Dry.			Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt and clay.	Effective sign.	Uniformity coefficient.
										Mm.	
1	Blue..	Brown	Test pit down Chagres River.	Very fine sand and clay.	....	......	4.2	18.3	77.55	0.009	3.3
3	...do..	...do..	.....do......	Fine sand and clay.	0.03	26.2	44.7	6.2	22.62	.025	7.0
2	Brown	...do..	Test pit Gatun Island.	Sand and clay.	0.2	7.6	12.0	6.6	73.6	.008	4.1
4	Blue..	Blue..	.....do......	.....do.......	2.2	11.4	24.0	4.8	57.6	.009	3.3
6	...do..	Gray .	.....do......	.....do.......	0.5	19.4	46.7	7.4	26.8	.022	6.3

SEEPAGE TESTS OF SOILS AND MATERIALS IN PLACE AS DETERMINED FROM THE BORE HOLES.

In order to obtain some information regarding the character of the soils as water carriers in the Chagres Valley in the vicinity of the dam site careful measurements were made (1) of the height the water would stand naturally in the bore holes; (2) of the rate at which water would return to this level if the casing were filled or pumped out; (3) of the height to which water would naturally rise if the casing was overflowed; and (4) of the quantity that would be discharged in case of a flowing well.

On Plates 89 to 94, inclusive, are shown typical diagrams of the rates of rise or fall of water in the casing. The complete set of these diagrams is on file with other records. Plates 95 to 98 show the average conditions that were found, and on Plate 99 are tabular statements of the data found from tests in various holes reduced to a uniform head of 10 feet for comparative purposes. The following description is given of these plates:

Plate 95 shows a curve platted from a seepage test in hole 928, Gatun dam site. The horizontal line representing zero (0) head is the point at which the ground water came to rest in the bore hole. The ordinates represent the time and the abscissæ the head of water in the casing, referred to the ground-water level. The casing was pumped out a few feet above or below the level of the ground water, and then soundings were taken, note being made of the position of the water at chosen instants of time. These points were platted and a smooth curve passed through them as shown on Plate 95.

At any given instant the water is moving with a certain velocity, depending upon the head. By drawing a tangent at any point on the curve the velocity of flow (uniform for the instant chosen) will be represented, and, where it touches the curve, a horizontal line drawn to the axis will give the head which produced that velocity. Plate 95 shows the tangent drawn, intercepting 2 feet vertically and 10 minutes horizontally, the head being 0.5 foot. The velocity, then, for that instant is 2 feet per 10 minutes under 0.5 head. Referring to the table, for hole 928 in the column marked "Rise" will be found 2 feet (the velocity per 10 minutes), and under "Head" 0.5 foot. In

the above manner all the data were derived which are found in the table. To obtain the rate a formula was devised taking into account the area of the bore hole and the movement of water per unit of time (1 minute). The area of a $2\frac{1}{2}$ inch casing is 0.034 square foot, therefore

$$\text{Rate} = \frac{.034 \times \text{movement (rise or fall) in 10 min.}}{\text{time (10 minutes)}} = \frac{.034 \times \text{movement}}{10} \quad (1)$$

To reduce the rate to a uniform head, this formula must be modified. From experiments on the flow of water in wells and from the formulæ for such flow it is found that the rate is directly proportional to the head. Therefore, to include the head, it is necessary to assume a standard (for convenience, 10 feet), multiply by this head, and divide by the head taken from the table.

$$\text{Rate} = \frac{(.034 \times \text{movement}) \times 10}{10 \times \text{head}} = \frac{.034 \times \text{movement}}{\text{head}} \quad (2)$$

This formula reduces all the rates to correspond with a uniform head of 10 feet. It is noticeable, in the table, that the rate for the "rise" and for the "fall" of the water in a given hole is not the same. For the present purpose the rates were averaged. As an example of the method of using the formula consider hole 928. The rise and fall are each 2.0 feet and the head 0.5, so one curve will serve for both.

Rate $= 0.07 \times 2 = 0.14$ cubic foot per minute under a 10-foot head as given in the table under "Rate."

The materials opposite each hole in the table are those through which the bore hole pierced between the bottom of the casing and the bottom of the hole. In other words, they are the exposed materials through which the water passed into or out of the hole. After all the rates were determined, they were grouped according to the material into three classes, namely, "clay," "clay and sand," and "rock," and the average taken of each group. These average rates will be found written on the curves of Plate 96. These curves were platted as follows:

The rate, for instance, 0.11 cubic foot per minute, for "clay and sand" was divided by 0.034, the area of the hole. This gives the velocity of flow for 1 minute under a 10′ head in the casing.

$$\frac{0.11}{.034} = 3.235 \text{ feet movement during the first minute.}$$

This distance is measured up from the zero (0) of coordinates on the line representing 1 minute. Substracting 3.235 from 10 gives 6.765, the head acting at the end of the first minute,

$$\frac{3.235 \times 6.765}{10} = 2.19 \text{ feet, the movement during the second minute.}$$

$2.19 + 3.235 = 5.425$, which is measured up from the horizontal axis as before on the line representing the second minute. These two points are on a tangent to the velocity curve for "clay and sand." A number of points were located in this manner, then joined by straight lines, and a smooth curve drawn tangent to these lines at the middle points. These curves have such a quality that, if a tangent be drawn at any point, and the movement for 10 minutes and the head corresponding be substituted in formula 2, the result will be 0.11.

In other words, the velocity varies with the head. The curves for "rock" and "clay" were platted in a similar manner, using their respective rates—0.07 and 0.04, divided by 0.034 as above.

So far, no attention has been paid to the depth of exposed material. By dividing the rate for each material, as given on Plate 96, by the area in square feet of the exposed material, the rate per square foot is obtained. The average depths and areas are as follows:

	Square feet.
Clay and sand, 34 feet by 0.655	22.3
Rock, 43.5 feet by 0.59	25.7
Clay, 35.5 feet by 0.655	23.25

The diameter of the holes piercing "clay" and "clay and sand" was assumed as 2½ inches, giving a circumference of 0.655 foot. The diameter of the bore holes in "rock" was assumed as 2¼ inches, giving 0.59 foot circumference. The rates, 0.11, 0.07, and 0.04, divided by the respective areas give 0.005, 0.0027, and 0.0017, the rates per square foot under a 10-foot head, as shown on Plate 97. The curves on Plate 97 were constructed in the same manner as those on Plate 96, by dividing the rate by 0.034 to obtain the velocity in the casing. It should be noted that these curves represent the velocity in the bore hole, not the velocity of flow in the material itself. The velocity in the casing is much greater than that in the material, because the area is less than 1 square foot. Plates 95, 96, and 97 were constructed as a means of comparison with the original curves platted from the field data of the seepage tests.

Plate 98 gives the results obtained, and from it the velocity at any head may be found. For instance, the velocity under an 8.5-foot head in "clay and sand" is 0.0000705 second-foot. Under an 85-foot head it would be 0.000705 second-foot. These results are an average; particular sections or strata might give a velocity greater or less than the above. The greatest velocity obtained by working out 34 tests in various materials was 0.00045 second-foot with 10-foot head in hole 905.

COMPARISON BETWEEN SEEPAGE IN EXPERIMENTAL DAM AND SEEPAGE THROUGH "CLAY AND SAND" OF BORINGS.

Referring to Plate 97, the rate of flow per minute per square foot of exposed material—"clay and sand"—is 0.005 cubic foot under a 10-foot head. In the experimental dam it is shown that the seepage, when the flow had become constant, was 0.000029 cubic foot per second per foot width of dam. The corresponding height of saturation was then a maximum, and was about 20 inches. The height of saturation in the dam may be called the head, and its upper limit the point of zero (0) head or the ground-water level, similar to that in the bore holes. As the extreme downstream gauge where the water passes into the air is chosen, the 20 inches may be compared to the exposed material in the bore holes, and the area $=\frac{20}{12}=1.7$ square feet per foot of dam. Taking the rate of 0.005 for "clay and sand," which material is similar to that in the dam, $\frac{0.005}{60}=0.00008$ cubic foot per second per square foot under a 10-foot head, which is the velocity with which water passes through a square foot of material into the bore hole. If 0.005 had been first divided by 0.034, the result would have

been the velocity in the casing. To compare the two velocities, the head in each case must be the same. The head in the dam is equal to the height of saturation, or 1.7 feet. Reducing the velocity to that for a 1.7 head gives

$$\frac{0.00008 \times 1.7}{10} = 0.000014 \text{ foot per second.} \qquad (1)$$

Since the seepage in the dam is 0.000029 cubic foot per second per foot width, and the height of saturation is 1.7 feet, the velocity is

$$\frac{0.000029}{1.7} = 0.000017 \text{ foot per second.} \qquad (2)$$

A comparison of results 1 and 2 indicates that the materials in the upper portion of the deposits in the Chagres Valley at Gatun are similar in point of permeability to those used on the model dam. The river-bed sections in Plate 100 show that the velocity of underground flow has a tendency to vary inversely as the depth of the stratum in which it occurs.

ROCKS—FRICTIONAL RESISTANCE.

Tests have been made of the various rocks that predominate in the vicinity of Gatun, and on Plates 101 to 103 are shown the results of these tests, and on Plate 104 the apparatus used in this work.

Table No. 4 (below) shows various physical properties of the materials.

TABLE 4.

Sample No.	Material.	Condition.	Weight and specific gravity.				Absorption in 24 hours after being dried at 212° F.		Abrasion.
			Dried at 212° F.		Saturated.				
			Weight per cubic foot.	Specific gravity.	Weight per cubic foot.	Specific gravity.	Per cent by weight.	Per cent by volume.	Loss in 15 min.; 40 pound pressure. 10 inches.
1	Blue sandstone.	Soft coarse grain.	83.5	1.34	111.2	1.78	34.3	46.0	12.6
2	Volcanic ash....	Soft white, some gravel.	58.8	.94	88.9	1.42	51.2	48.2	21.4
3	Volcanic tufa...	Hard and brittle.	89.5	1.43	108.9	1.75	21.7	31.1	2.6
4	Conglomerate..	Hard black......	103.1	1.65	115.7	1.85	12.2	20.2	22.7
5	.....do..........	Hard brown.....	102.5	1.64	127.6	2.04	24.5	40.2	11.7
6	Volcanic ash....	Soft gray........	41.3	.66	80.2	1.27	94.2	62.3	100.0
7	Conglomerate..	Gray.............	101.6	1.63	125.4	2.01	23.4	38.1	8.7
8	Argil sandstone.	Dark soft........	103.2	1.65	113.2	1.81	9.7	16.0	17.0
9	Gray sandstone.	Fine grained.....	88.7	1.42	111.7	1.79	25.9	36.9	20.0
10	Brown sandstone.	Coarse grained...	96.3	1.55	131.2	2.10	36.2	55.9	45.3
11	Bas Obispo rock.	Hard and compact.	150.9	2.42	152.4	2.44	.99	2.6	No test.
12	Bas Obispo conglomerate.	.....do	150.8	2.41	151.6	2.43	.53	1.3	No test.

The tests were made to determine the permeability of the rocks under various pressures, and the loss by erosion when exposed to a pressure of 40 pounds, equal to a head of 92.3 feet, the greatest possible head to which they may be exposed in contact with the waters of the lake. The samples were collected from the various localities in their natural condition and tested or kept under water to protect them until ready to be used.

APPARATUS AND METHODS USED.

For the permeability tests 6-inch nipples 36 inches long and 2-inch nipples 18 inches long were used. (Plate 62.) This figure shows two large nipples, one 8 inches and the other 6 inches in diameter, in which have been made percolation tests of soils and rocks under high pressure. The smaller nipple shows gauges at two points in the specimen tested, and with them it was possible to obtain information concerning the variation of the discharge due to the difference in the length of the medium. The four small nipples at the base of the 8-inch nipple were used in obtaining information concerning strata which was available only as diamond-drill samples. These nipples were also used in the abrasion tests. When possible to obtain them, cores 4 to 5 inches in diameter and 12 to 18 inches long were placed in the 6-inch nipples, and after being wedged into place, neat cement was poured in between the nipple and the core and allowed to set thoroughly. One end of the core was placed about 6 inches from the end of the nipple and this space filled with coarse gravel to prevent the bonding cement being broken by the pressure of the water. The nipple was then connected to the water main and the pressure regulated as desired and the seepage measured. Some of the materials were so coarse grained and brittle that cores 1½ inches in diameter and 6 to 12 inches long were the largest possible to obtain. The small cores were placed in 2-inch nipples 18 inches long in the same manner as the larger cores in the 6-inch nipples. (Plate 104.)

For the abrasion tests 1½-inch nipples 9 inches long were used. Diamond drill cores of the various materials 1 inch in diameter and 4 to 6 inches long were used. These cores were first thoroughly dried and then accurately weighed. They were then cemented into the nipples, one end of the core being placed about 1 inch from the end of the nipple. After the cement was thoroughly set the nipples were again weighed, a hole one-fourth inch in diameter was drilled through the core, and the nipple with the encased core a third time weighed, the weight of the core after drilling thus being obtained. The nipple was then connected to the main, and a steady pressure of 40 pounds maintained for fifteen minutes, one end of the nipple being open. The nipple was then thoroughly dried and weighed, and the percentage of loss by erosion thus obtained. The weight of the various materials dry was obtained by determining the specific gravity of each material, but as the apparatus was limited the results are only approximate.

Materials tested.

Sample 1.—A coarse-grained blue sandstone from a test pit near lock site. As some volcanic ash is present, the material is brittle and crumbles easily. On account of its porous nature water passes through it rather freely, and for the same reason the loss by erosion was not comparatively large as the water passed through the whole core.

Sample 2.—A soft, gray, volcanic ash from the lock site. The material is brittle, but rather firm, and contains considerable sand and some gravel. On this account it is not very impermeable, and because of its large percentage of ash easily erodes.

Sampl 3.—A hard, compact, volcanic tufa resembling rhyolite, which becomes soft and disintegrates when exposed to the air. This sample was obtained from an outcrop about 1,000 feet from the fire department house in Gatun. It was impervious under a pressure of 90 pounds, equal to a head of 207.6 feet, and eroded very little when brought into contact with water.

Sample 4.—A dark conglomerate, similar in structure to dark argillaceous sandstone. The gravel in this material forms a small percentage of the whole mass and is of large size. This rock is practically impervious, but is easily eroded.

Sample 5.—A brown conglomerate from the lock site, the cementing material being volcanic ash. As the larger part of this mass is gravel, it is heavy and dense and almost impervious, but on account of the ash it is easily eroded.

Sample 6.—A very soft, light, gray volcanic ash from the lock site. The material is almost pure ash and can be easily crushed between the fingers. It is very fine grained and compact, and on this account nearly impermeable when confined in place, but when openly exposed to pressure it is easily washed away.

Sample 7.—A light, blue-gray conglomerate similar in texture and ingredients to sample 5, and the results of 5 and 7 are practically the same.

Sample 8.—A dark-blue argillaceous sandstone from the spillway test pit. The rock is medium hard, fine grained, and compact, but disintegrates rapidly when exposed to the air. On account of the large percentage of clay this material is rather impervious, but easily eroded.

Sample 9.—A light-blue sandstone from spillway test pit which turns gray when exposed to the air. This rock is similar to sample 8, but contains much more sand and less clay, and is more pervious under a high pressure.

Sample 10.—A light-brown sandstone from spillway test pit. Composed of sand and fine gravel, only fairly impervious, and easily eroded.

Samples 11 and 12.—Andesite and breccia from near Bas Obispo. Were picked at random from the dump and are intended to be representative of the materials deposited in this fill.

Plates 101, 102, and 103 show the comparative results of the tests of the different rocks. From the tests it seems to appear that the permeability of water passing through varied directly as the head applied, and that the loss in head varied directly as the length of the specimen. It also appears that the loss of head through five of the rocks was total in 1 foot of material under 80 pounds pressure, and that through 3 feet all the rocks would show a total loss of head under the same pressure. The loss by erosion is in each case much larger than it could possibly be under actual conditions, but gives a good comparison of the stability of the various rocks.

The following tabular statement (No. 5) indicates the chemical composition of the several rocks as found near Gatun. Analyses made at the Ancon chemical laboratory April 9, 1908.

TABLE 5.

	Argillaceous sandstone from spillway.	Gatun red clay.	Blue clay and sand, pit No. 54.	Volcanic ash, Gatun Hill.	Conglomerate.	Argillaceous sandstone.
Chemical No	152	153	154	155	156	157
Sample No	I	II	III	IV	V	VI
Water in crude sample	....	30.78	33.83	....	....	....
Ammonia, free	....	.0027	.051	....	....	....
Albumenoid	....	.0125	.065	....	....	....
Moisture in powdered sample.	10.65	6.03	2.70	11.21	8.15	7.04
Loss upon ignition	11.30	12.56	10.62	5.68	7.49	10.08
Silica	39.46	38.08	51.20	57.74	51.36	43.76
Alumina and ferric oxide*	38.00	43.66	31.10	19.60	29.34	27.66
Calcium oxide	.34	.16	2.76	2.04	1.86	7.22
Magnesium oxide	1.64	1.14	2.18	1.30	.56	3.45
Sodium oxide	....	....	.95	1.98	.90	1.14
Potassium oxide	....	....	.43	1.93	.63	1.35
	101.39	101.62	101.94	101.48	100.29	101.70
*Ferric oxide	9.60	10.88	8.40	2.24	6.56	8.24

SOILS—FRICTIONAL RESISTANCE.

These experiments were made to determine the frictional resistance to water of the soils in the Gatun region.

APPARATUS AND METHODS USED.

For the purpose of these experiments six galvanized-iron tanks were used. (Plate 63.) They were of old French stock, and formerly used as water reservoirs. They were 39.36 inches (1 meter) in diameter and 54.50 inches high. The area was 8.45 square feet, or $\frac{1}{5155}$ acre. The tanks were coated inside with a covering of pitch and coarse sand. In the center of the bottom a connection was made to a 1-inch pipe, on the end of which was a swinging elbow. The hole in the bottom of the tank was protected by a piece of wire screening. It was intended to equip these tanks similarly to those used by Hazen. The general manner is shown in the sketch. (Plate 105.)

So far as possible, an effort was made to deposit the material in the tanks in condition similar to that when found in place. Every endeavor was made to drive out all the air from the material, and a constant head of water was maintained, the water entering from a large snout on the side of the tank and discharging from the same as shown in the figure. (Plate 105.) The head of water was shown in the gauge glasses, and the difference between the elevation of the water surfaces in the upper and lower glasses indicated the head lost in friction while the water was passing through the material. By means of the swinging joint the outlet of the tank could be raised or lowered and thus the discharge regulated. The endeavor was to obtain such a discharge that the head lost in friction would equal the length of the soil column. This made $\frac{h}{l}$ (=hydraulic grade line) = 1. This discharge is called by Hazen the "maximum discharge," and when it is determined, the discharges for any other ratio of "h" to "l" is readily calculated, knowing that the discharge varies directly as the slope of the hydraulic grade line—sin i. The tests were continued from two to six weeks, or until the seepage became constant.

For testing soils under pressure, an 8-inch nipple, 4 feet long, was used, and fitted up as shown in Plate 106; 36 inches of material was the usual depth of the column.

Materials tested.

[For mechanical analyses, see Table 19.]

I. Stiff blue clay from test pit down the Chagres River north of the dam site.
II. Red sandy soil from embankment slope of spillway hill.
III. Medium fine sand from test pits down Chagres River.
IV. Brown sandy clay from Gatun Island test pit between surface and 13 feet below.
VI. Blue sandy clay from Gatun Island test pit from 15 to 37 feet below surface.

A constant head of 11 inches of water was maintained, and the top sand layer was frequently scraped. The temperature of the water was about 86° F.

TABLE 6.

Sample No.	Effective size (diameter in mm.).	Uniformity coefficient.	Porosity (per cent).	Maximum rate (cubic feet per acre per 24 hours).	Velocity (foot per minute 1:1 gradient).	Duration of experiment (weeks).
1	0.0025	12.3	59.16	49.9	0.0000077	4
2	.005	9.0	57.69	226.7	.0000037	4
3	.05	4.8	54.71	206.7	.0000033	4
4	.04	12.5	50.45	136.4	.000002	6
6	.01	11.5	47.99	295.7	.000015	4

No. VI was tested under pressures of 50 pounds (h = 115.3 feet) and 80 pounds (h = 184.5 feet) per square inch. The test was continued for sixteen days, and the constant flow established was 1.94 cubic feet for eight hours (a rate of about 1.8 gallons per hour). This is equivalent to a rate per square foot of 0.000193 cubic foot per second under the former pressure. Under the latter pressure the discharge was 3.39 cubic feet for eight hours, equivalent to a rate per square foot of 0.000338 cubic foot per second. The relationship of head and discharge in this case is shown to bear out the assumption of the direct proportion.

EXPERIMENTAL DAMS.

In order thoroughly to test the materials and methods available for the construction of the Gatun dam, experiments were made similar to those made at Clinton, Mass., for the Metropolitan waterworks.

A large, water-tight, wooden tank was constructed having inside dimensions 75 feet long, 6.08 feet wide, and of height sufficient to take the proposed dam. This tank was set up on the bank of the Chagres River just north of the site selected for the dam. The elevation of the bottom of the tank inside was about 11 feet above sea level.

In this tank the experimental dam was constructed entirely by hydraulic methods and exactly similar in shape to the proposed dam, but on a scale one-twelfth as large; that is, 1 inch in the experimental dam corresponded to 1 foot in the actual dam. It did not, however, seem necessary to include the whole of the long downstream slope, and the tank was shortened 25 feet, corresponding approximately to 300 feet in the original design. This made the hydraulic fill portion equivalent to about 885 feet of actual dam. The height of the sides of the tank on the upstream side for a distance of 22 feet 8 inches was 8 feet 7 inches, or sufficient to allow a head of 100 inches to be placed against the water face. From this point it ran upward on a 3 on 1 slope till it reached a height of 11 feet 7 inches, sufficient to take a height of material corresponding to 135 feet in the actual dam. The top of the sides was then run level for 9 feet 3 inches, and then dropped on a 3 on 1 slope to a height of 7 feet 10 inches, and continued on this elevation to the end. The outline of this dam is shown on Plate 107, and photographs of the tank are shown on Plates 64 to 67, inclusive. The material was all yellow pine lumber, the uprights being 8 by 8 inches, and the sides 2 by 12 inch stock. These planks had their edges slightly beveled, and all joints were

tightly calked with oakum. On the inside about every 4 feet, rough 2 by 4 inch scantling was placed on sides and bottom to make stops so that water might not find its way between the sand and the planking. After this, the entire inside was coated with pitch into which sharp sand was thrown to further improve the bond.

At intervals of 4 feet 1½-inch galvanized-iron pipes perforated with one-fourth-inch holes were placed across the tank near the bottom, the ends being threaded and passed outside the tank. These pipes were covered with wire gauze, and later with a little fine gravel. Each of the projecting ends of these pipes were held with lock nuts outside the tank, in order that caps and pipe might be screwed on without disturbing the pipe and its connection with the tank, and so cause leakage.

During the experiments the tank was absolutely tight. On the easterly side of the tank these pipes were capped so that they could be used for drainage, or for flushing out the pipes if they became clogged with sand. On the west side a tee branch was screwed in, and into the horizontal end was screwed a nipple with a cap on the end. Into the vertical opening was put a wooden reducer, and into this one-half-inch gauge glasses reaching to the top of the tank. (Plate 64.) These tubes were for the purpose of observing the slope of saturation in the material, and constant readings were taken of the elevation of the water by means of gauge boards placed behind each glass. At the north or downstream end of the tank was a portion about a foot wide partitioned off and forming an open space into which water could freely run from the sand in the dam. One-half-inch holes on 2-inch centers were cut in the partition and covered with netting to hold back any sand. Out of the open space a pipe was run to a measuring tank, and, after the experiments were begun, constant readings were taken of the amount of water percolating through the dam. The water against the face of the dam was kept at a constant height by overflows at different elevations, and a continuous flow of water maintained by feeding from an auxiliary tank. For the intake at the water face, precautions were taken to allow the water to flow in at the bottom, but in such a way that there was no danger of washing the material.

It was expected to build two types of dam; one with the material all delivered at the downstream face and discharging over the upstream slope, which would allow the material to grade itself from coarse to fine, the more impervious portions being placed on the water slope; the other type was that usually adopted in hydraulic-fill dams—that is, depositing the material on both slopes and allowing it to flow toward the center of the dam. On account of this design, outlets were arranged at both the upstream slope and in the middle of the dam. The upstream overflow had two openings, each 12 by 24 inches, while in the center the opening was 10 by 18 inches. After completion and during the time the water was against the dam, these openings were tightly wedged in place and calked to prevent leakage. In order to take care of the overflow water in the second type, it was necessary to construct a weir box on the inside of the westerly wall of the dam, and sliding boards were used to regulate the discharge. On the upstream face cleats were nailed on a 3 on 1 slope, and in these could be dropped flashboards to hold back the water and regulate the discharge during construction of type I. In order to hold the water

at any desired elevation, 1-inch pipes were run through the south or water end and capped. These pipes were at distances of 10 inches apart, and the water could thus be held at any elevation by uncapping one of these pipes. Every 18 inches along the bottom one-half-inch holes were drilled on each side of the tank so that the material in the dam could be thoroughly drained. These holes were closed by wooden plugs during the tests. An observation platform was built around the top of the tank, and the whole was covered by a galvanized-iron roof to protect from rain and winds.

The pumping apparatus consisted of a 6 by 8 inch double, upright, reversible French engine which was taken from a crane that had been lying in the jungle for probably twenty years. This was belt connected to a 10½ by 8½ inch French centrifugal pump from one of the old ladder dredges found at Miraflores. This pump was bushed down to an 8-inch suction and a 6-inch discharge. This later was reduced to 4 inches on entering the tank. The steam was furnished by two upright boilers also obtained from the jungle. Both of these were refitted, tested to 175 pounds, and run at 100 pounds steam pressure. The material came from an area at the end of Spillway Island, on the west bank of the Chagres. The area and location from which this was taken was chosen that it might be as nearly as possible representative of the materials to be subsequently used hereafter in constructing the proposed dam. The surface deposit was cleared off, leaving only a very thin layer of yellow loam and clay in which were some pockets of pure sand. Under this was a bed of compact blue sandy clay which formed the bulk of the material used. It was loaded into an old French coal barge, and towed to the pump at the dam. The pump suction was a flexible rubber pipe, and could readily be transferred into either of the two compartments into which the barge was divided. (Plate 68.)

After several trials, the best way to handle the material was found to be as follows: After the barge was moored in place at the pump, two 3-inch syphons primed by steam were placed over the side, and sufficient water continuously drawn from the river to keep the material in the barge in suitable condition for pumping. Four to six men shoveled the material into a wooden trough which was tilted under water to the suction pipe, and thus a constant supply was maintained. The discharge pipes were connected up with 4-inch flexible joints, and could be readily moved in any direction. On account, however, of the great velocity with which the water was discharged, it was found necessary to first discharge into a trough, which would reverse the flow, sending the water against the end of the tank. (Plate 69.) Here it was again reversed, and by this time had lost enough velocity to allow the materials held in suspension to settle into place. This difficulty, of course, will not be encountered in the actual dam, as the distance to the overflow will be so great. On account of delays occasioned by the nonarrival of lumber and other materials, the actual work of dam building did not begin until April 1. As mentioned above, the material by this method graded itself from the coarsest portion at the downstream end to the finest at the upstream face. This material, which was a fine yellow silt, was very unstable, and had the consistency of a thick mud carrying considerable water. Some difficulty was experienced in making it hold to any slope under the wash of the discharging water. Boards, grass, burlap,

and wire netting were all used to hold it in place and protect the slope as built from the overflow above. During this period the endeavor was to lose as little as possible of the material pumped, the theory being that the finer the material deposited, the more impermeable would be the upstream face, and the pumps were run two minutes with a rest interval of five minutes. After several trials, this rate was found to give the best results, and the overflow was almost clean water. The velocity maintained on this tank and found to give the best results was about 2 feet per second at the intake end. If at any time it appeared that a layer of silt was being deposited over the downstream portion, it was broken up by walking over with bare feet while water was discharging. For the first 25 feet from the downstream end, the material took a 1 on 50 slope, and for the next 5 or 6 feet, a 1 on 6 or 7 slope. All of this could be walked on immediately after the pumping stopped. The remainder of the material was a blue and yellow silt with very little sand and an almost flat slope. This settled very slowly, and when there was nearly 5 feet depth in place, only 6 or 8 inches was stable enough to support the weight of a man.

Samples of the material pumped were regularly taken in long glass tubes, but they varied greatly, due to the irregularity with which the pump was obliged to be operated. At the inlet the average of these samples in one hour's settlement was about 10 per cent sand and about 70 per cent clay and silt. After twenty-four hours they would show about 50 per cent sand and 30 per cent clay and silt. At the outlet most of the time the samples showed no sand and about 10 per cent clay and silt after twenty-four hours' settlement. Thus it appeared that a great proportion of the material excavated was being saved. On April 11 pumping was discontinued in order that the condition of the upstream slope might be ascertained, as it was felt that its condition was not satisfactory. Samples of this portion would ooze out when the drainage plugs were pulled; this would dry in the sun and become almost stone-like. If placed in water, after twelve hours the pieces would lose their shape, and, if shaken, would discolor the water like mud. After examination, it was decided that too much of the fine material had been held back and it was determined to remove the unstable portion.

Previous to this, however, on April 14, a quantity of the material was placed in four test boxes, two being filled with material from near the downstream face and the other two from near the center of the dam. These boxes were 12 inches wide, 14 inches high, and 48 inches long, and the bottom was covered with slats on which was placed mosquito netting. The samples taken from near the toe of the slope were almost pure clay and silt with no sand. Those taken from near the center of the dam had a considerable portion of very fine sand. On April 21 the boxes were tilted in order to give the material a chance to settle to a 3 on 1 slope, which it gradually did very slowly, although exposed top and bottom to the air. Cracks developed on the surface even while the center was wet. On June 5 the material had settled to about 70 per cent of its former bulk, and had the consistency of freshly made cheese. Solid wood bottoms were now placed in the bottoms and made water-tight by pitching. Water was then turned on and a constant head maintained. On June 27 no change was found in the slopes which, previous to turning

on the water had been trimmed to a true 3 on 1 slope. The surface of the material for about one-sixteenth of an inch was unstable and muddy, but the remainder was firm and solid and had a greasy feeling to the touch. Evidently it was stable and thoroughly waterproof. On August 1 this same condition was apparent, and there seems no question but what the material will not dissolve under the action of water similar to that to which it is here exposed.

After the samples were taken, all the upstream material from the center was washed out, leaving the solid material in the tank, as shown by the dotted line in Plate 108 and marked "4/16/08." Similar material to that which had been previously used was again pumped in, starting on April 20. The attempt now was to retain only such material in the upstream slope as was similar to that found in the center of the dam—clay and silt with some very fine sand—and it was now possible to walk over any portion of the dam almost immediately after pumping. Measurements were taken of the material in the dam and of that pumped from the barge, and it was found that about 40 per cent of the amount pumped was actually deposited. The velocity in the tank was about 2 feet per second over the entire length. On May 10 this dam was completed. The material on the water slope was now found to be in excellent condition. A layer of gravel 1 to 2 inches thick was then placed on this face, and over this was placed a layer of crushed stone 4 inches at the top and 24 inches at the bottom. The dam was now allowed to drain for three days, and on June 14 water was admitted to the upstream face at the rate of 1½ inches per hour till it reached elevation 18, and from there on it was raised at the rate of 1 inch per hour.

Continuous readings of gauges and percolation tank were taken from the time the water was first turned on until the experiments were finished. The curves on Plates 109 to 119 show the rate at which the slope of saturation rose in the dam and Plate 120 shows the seepage during the test. As the water was put on before the dam was thoroughly drained, it is very probable that some of the height shown in the earlier diagrams is due to water that had not drained out, rather than to seepage water from the upstream slope. All of the curves show a marked change near the center of the dam. Referring to Plate 108 and looking at the dotted line marked "4/16," it will be seen that the position of this distortion corresponds nearly with the slope on which the soft material was pumped out, as mentioned above. By studying the dotted lines on the plate and comparing with the next slope line taken in point of time, it appears probable that when the water was applied after washing out the soft material it first cut down the steep slope near the center of the dam. The fine material here was washed to the bottom of the tank and immediately covered with other material, until the whole slope was changed and upbuilding again began. The probability is, therefore, that along this portion the material was very much finer and more impervious, and the steepening of the slope shows what effect permeability may have on the hydraulic grade line. The variation in the points shown on Plate 120 for the rate curve is undoubtedly due to carelessness in reading or in time of taking reading. Except two white men, all the help was black and of uncertain education and reliability. The results were checked each day by white observers, and during the last week, when the rate had become constant, two white

observers took independent readings. A head of 85 inches was retained on the dam until the seepage had without doubt reached a constant quantity. In order to test the stability of the upstream slope, the water in the tank was lowered 40 inches in fifty-two minutes. The drainage of the slope was found to be perfect, and no tendency to slide was apparent. In order to demonstrate that the water in the experimental dam was proportional to that which might be expected in a structure twelve times as large, the water against the dam was held for about a month at elevation 45, or about one-half that previously used. Careful observations were taken, and the results are shown in Plates 121 to 130. As expected, these results confirmed the belief that the variations in discharge were directly proportional to head and area. More detailed description of this is given on page 146 et seq.

In order to construct another model dam (called II) in the tank, it was necessary to get rid of the present materials, and they were washed out by a hose stream. During this operation it was found that the material was very solidly packed. Previously to the washing out test pits were sunk into the dam at intervals and samples obtained for mechanical analyses and porosity. On Plate 131 is shown a section of experimental dam—Type I contoured to show distribution of material with reference to its effective size. The curve of saturation during period of maximum discharge is shown by the irregularly sloping line A–B. Its section of maximum declivity is plainly seen to coincide with the fine materials left in the dam after the washing out mentioned. The line 4/16/08, Plate 108, is reproduced on Plate 131. The mechanical analyses of these samples follow:

TABLE 7.

Sample designation.	Elevation from bottom.	Classification.		Per cent by weight.			Effective size in millimeters.	Uniformity coefficient.
		Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt and clay.		
	Inches.							
A	12	5.0	20.4	42.0	9.0	23.6	0.018	8.7
B	12	2.0	14.0	31.0	10.0	43.0	.01	9.0
C	12	4.0	29.0	44.0	10.0	13.0	.026	7.1
D	12	.4	8.6	45.8	22.8	22.4	.02	6.5
E	12	1.4	18.0	52.0	10.6	18.0	.024	6.2
F	12	1.0	7.0	51.0	15.0	26.0	.019	7.4
A	45	.8	27.0	48.0	12.8	11.4	.04	4.8
B	45	.2	18.0	58.8	10.6	12.4	.035	4.1
C	45	.4	6.8	43.9	23.0	25.9	012	10.4
D	45	....	3.8	37.4	31.2	27.6	.015	7.0
E	45	....	2.4	45.4	25.7	26.5	.015	7.2
A	74	7.2	11.2	39.0	10.6	32.0	.02	6.6
B	74	2.0	26.0	50.8	6.2	15.0	.025	5.2
C	74	2.2	16.6	55.6	13.6	12.0	.04	3.6
D	74	.6	10.2	43.6	17.4	28.2	.016	6.2

The evenness of the stratification in the model dam as exposed by test pits was very satisfactory, and the fact that the sides of the pit remained vertical for a week was evidence of the solidity of the structure. In flushing out the material near the face it was necessary to cut furrows along the surface and gradually widen them, otherwise the hose stream only bored holes in the embankment. Back of the center line the method employed was to undercut, and when the mass

dropped, break it up and wash it out. There was question if some water might not have found its way along the side or bottom of the tank in spite of the 2 by 4 inch water stops. This, however, was settled by the character of the material at the stops. These latter had acted as baffles and so greatly reduced the velocity that the finest materials had banked around the stops and here was the most impermeable place of all. As had been expected from the character of the saturation slope, much fine material was found concentrated near the bottom and at the center of the tank.

MODEL DAM II.

The general method of construction of this dam, as has been stated, was to discharge materials on both slopes and allow them to grade from coarse to fine from the outer slopes to the center. The inlet pipe was brought up over the center of the dam (Plate 65) and discharged both ways in a manner similar to that previously described. The outlet was regulated by 6-inch stop planks in the weir box. The upstream slope was easily regulated by 1 by 12 inch boards placed at intervals on the slope. It was apparent from the start that this type of construction was much to be preferred so far as ease in building was concerned. The material for this dam was obtained in the same place and by the same methods as described for use in type I. Pumping began July 21, and the dam was completely finished August 10. During construction deposits of silt left on top of the sand by the last of the draining could be washed off by pumping clean water for a very short time. Regulating to deposit sand or clay as desired could be done by placing the discharge end above or below the water surface. In this way sand could be deposited in slopes varying from 1:33 to 1:11, while the finer and compact materials at the center took a slope of 1:15 or 1:18. The length of the pumping time varied as the embankment rose and the slopes narrowed in. In the first place, five-minute intervals were used, but at the last one-half-minute intervals were necessary. During these times the discharge through the weir box varied from 0.4 to 1.1 cubic feet per minute. The actual pumping time for discharging the first barge load was not taken, but the second, containing 52 cubic yards, was discharged in 236 minutes, or a cubic yard in four and one-half minutes, and the third, containing 63 cubic yards, was discharged at the rate of 1 cubic yard in five minutes. Much better time than this could have been made if it had not been necessary to consider the placing of the material in the tank. The distribution of the material is shown in Plate 132.

Of the first barge load, 47 cubic yards, or 81 per cent of the amount contained, was deposited in the embankment. Of the second, 34 cubic yards, or 65½ per cent, was held, and of the third, 38 cubic yards, or 60 per cent, was retained. The gradual increase in the amount wasted is due to the narrowing of the dam cross-section as it approaches the top, and the necessity of keeping the proper grading of materials. It is seen, therefore, that by this method of construction about 70 per cent of the material excavated was saved, against 40 per cent retained in the case of the former dam. The percentage saved would have been larger in the case of type II, except that, in order to hasten the work, the embankment above elevation 100 was pumped in almost continuously and much of the fine material wasted, as it was unnecessary to be particular with the portion above water level. Observa-

tions for seepage and saturation have not yet been begun in this [illegible] dam on account of allowing the material in the center to drain and consolidate by settling. A comparison of the different methods used in building the two cones of model dam showed—

(a) That the second method of construction was much the cheaper and quicker.

(b) No difficulty in obtaining downstream slope by method of central discharge in the second case, while in the first case it was almost impossible to hold it on account of washing.

(c) Relatively the construction in the second case is much more impermeable because so much greater a portion of the finer graded material is retained.

In the construction by the first method, it seems impracticable to retain the finer graded materials as they take the consistency of cream and have a tendency to slide under their own weight. These materials are what make for impermeability, and the more that can be retained without danger from sliding, the more water-tight the dam will be.

Under type (1) form of construction, the following are the conditions:

(1) An impervious dam of clay with some fine sand intermingled—a material which is almost impervious and not liable to crack and disintegrate.

(2) This dam is protected on the downstream slope by a more or less porous material. The function of this portion is to support the downstream face of the clay dam and prevent sliding. If any water percolates through the clay dam, the material supporting is so [illegible] gradation [illegible] given [illegible] saturation in the [illegible] of the rear portions [illegible].

(3) [illegible] of the dam [illegible] may be unstable [illegible] on a very flat slope. Here [illegible] into play, the [illegible] maxi- [illegible]. The angle of slope in the clay would be very flat [illegible] steeper and steeper as it approaches the outer edge where the sand is changed to gravel, and that to crushed stone. The outer material, which would stand on a very steep slope on account of its size, shape, and weight, is at an angle that would not be considered safe for sand. The weight of the stone facing, and the graded materials back of it is, therefore, at its maximum for holding the materials behind in place, and for resisting any tendency in itself to slip and slide out. The fact that it is saturated with water is of no account, as it is not intended to be part of the impervious portion, but merely by its weight to support the clay dam which forms the water-tight portion. The difference between "puddle core" and "puddle face" is in name only. The "puddle core" dam is nothing but a "puddle face" protected from sliding, erosion and attacks of water animals by facing of more resistant and solid materials.

Ideal conditions of this form of construction are shown in the section of the Necaxa, Mexico, dam in Plate 133. The prototype of the

Gatun dam is said to be the dikes built at Clinton, Mass., as part of the Wachusett Reservoir, and, as considerable adverse criticism has been made of this structure on account of a slide, it seems advisable to state the facts concerning this matter. On April 11, 1907, a portion of the face of this dam sloughed off and slid into the reservoir. On Plate 134 is shown the maximum section of this slide, detailed description of which is given in Engineering News, volume 57, page 464. The material on the water side of this embankment was sand, but it undoubtedly contained some soil excavated from the reservoir. This was deposited without the extreme care taken in the "cut-off," where the material in 6-inch layers was rolled well wet, and every precaution taken to make a water-tight and stable barrier. How stable it was is shown by the steepness of the slope at the upper end from whence the bank slid. On the water face of the embankment was a thick layer of gravel. About quarter way down this slope was a berm or shelf in the embankment, and on this and extending up the slope was placed a heavy facing of rock to protect the earth embankment from wave action. When the water in the lake had risen to about the bottom of the stone facing, which also extended somewhat below the berm, it had saturated also the underlying bank. Of itself, even when saturated, this material was probably stable on the given outer slope, but in this condition it was not able to sustain the weight of the stone facing. The weight of this caused the underlying materials to squeeze out, and it took a natural slope, as is shown in the section. The affair was an unfortunate occurrence, but it was not a disaster. There was never, at any time, the slightest danger of a crevasse that would have allowed the water of the lake to flow out, nor would there have been if the lake had been full. While this condition was not, of course, expected, good engineering had dictated precautions to provide for the unexpected. While it is felt that the Gatun dam, if built of the section proposed, would be perfectly safe, yet it is intended to take all the precautions to safeguard the structure.

To this end, it is proposed to drive sheet piling into the ground underlying the proposed embankment, and carry them to such a depth that percolation here may be reduced to a minimum. In the embankment, itself, it is proposed to build an impervious core wall that shall also be as impermeable as possible. This, it seems, can best be laid down by the hydraulic process. This method is chosen on account of the materials available, and the climatic and labor conditions which forbid the ordinary puddled core wall. The experiments thus far show that a core can be laid down in water by the methods proposed that shall be practically impervious. In the Gatun dam, on account of the methods to be employed, it will be possible to make this impervious portion many times thicker than is ordinarily deemed necessary in a puddle wall. In order to prevent any likelihood of such an occurrence as happened at Clinton, the upstream face of this puddle wall is protected by a big sand bank and on the water face of this is to be placed a protective coating of the hardest and most durable rock to be found on the Isthmus. (Plate 135.) Besides this protection, a solid barrier of rock and stone 60 feet thick and 300 feet wide is placed against the upstream toe, and this will resist any sliding tendency which may have been overlooked or underrated in the slopes given to the dam.

Plate 64 is a view of the experimental tank on its west side. In the foreground is the overflow for washing out material. To the left is an auxiliary tank for holding constant pressure on the main tank. On the sides of the main tank are shown the gauge glasses for observing the height of saturation in the embankment. In the center is the inflow pipe which brings the material from the pumps.

Plate 65 is a near view of the intake pipe and valves, and immediately below is the outlet where the water is discharged after having dropped its load of sand and clay in the dam. This pipe raises the material about 27 feet above the barge in which it is brought up the river.

Plate 66 shows the inside of the tank during dam construction. The wooden box which regulates the discharge may be seen, also the slope of the material during its deposition, and the solidity of it immediately after pumping may be judged by the weight of the man standing thereon. The material where he stands is about 3 feet deep.

Plate 67 is a view of the easterly side of the experimental tank in which is being constructed the model dam.

SLOPE OF SATURATION.

On Plate 136 are shown sections of dams and slopes of saturation found by borings made in the earth dams of the Croton drainage area by the board of engineers who examined the plans for the construction of the earth portion of the New Croton (N. Y.) dam in 1901. The slopes of saturation downstream from the core walls are shown as follows:

TABLE 8.—*Slope of saturation.*

	Feet per 100.
Bog Brook dam	30 to 40
Carmel dam	35
Middle Branch dam	21
Titicus dam	10.7
Amawalk dam	17 to 14.7

These slopes are much steeper than those observed in the experimental dam at Gatun, and are undoubtedly due to the materials used and the methods of construction. The board expressed that—

the slope of saturation in the best embankments made of materials in the Croton Valley is about 35 feet per 100, and, with materials less carefully selected, the slope may be 20 feet per 100.

In all of these dams the slope of saturation seems greatly influenced by the permeability of the material in place on which the embankment is built. In the case of the Carmel dam, either the rock may have been slightly porous or the toe of the downstream slope of such character that the water of percolation was led away as rapidly as it collected. In the case of the Middle Branch dam the material in the embankment was probably of sufficient porosity to allow the slope of saturation to cut the downstream slope of the dam above the base line. In all other cases the materials below the dam probably were at least as porous as those in the dam and allowed the water of percolation to run freely away. In Plates 137 and 138 are shown lines of saturation, as indicated by borings and observations in the north and south dikes of the Wachusett reservoir, at Clinton, Mass. The utility of the core wall and its action in restrain-

ing the flow of water, is remarkably attested by these diagrams, which need no other explanation. These dikes are similar to the proposed Gatun dam, and the rate of seepage through them and the height and character of the saturation slope are most pertinent to this discussion.

When a dam is first constructed, then is the period under ordinary conditions of maximum saturation slope, and therefore maximum discharge. If at that time the slope of saturation cuts the downstream slope of the dam at an elevation not higher than the point where the downstream slope cuts the horizontal base line, the condition is one of safety. This statement is conditioned by the proviso that the foundation is stable. The experiments at Gatun seem to show that, as might be expected, the hydraulic grade line upstream does not begin at the surface of the water when the embankment is sloping, but begins at a point the elevation of which is equivalent to the total head less the head lost in forcing the water through the face of the embankment. As the upstream slope is more and more compacted by the water, and as an impervious coating is found on the slope, due to the silt and other materials in suspension in the water, the elevation of this point grows less and less, the slope of saturation becomes flatter, and the discharge also becomes less. The dam is "silting up." The experiments on model dam, Type I (Plate 139), show that this slope would have cut the base line at a point about 100 feet upstream from the point where the downstream slope would have cut the base line. This condition would have been one of safety, and the probability is that additional security would have accrued as time went on. In the proposed dam, if the foundation were absolutely impermeable, the saturation line in time undoubtedly would cut the base line at its junction with the given downstream slope. To do this the slope of saturation must flatten and the seepage decrease proportionately. From the seepage investigations it appears that the sandy clay layer near the surface is probably not much different in its transmission constant than will be the material in the dam itself. On this account the slope of saturation in a dam built similar to Type I, previously described, undoubtedly would cut the base line at some distance back from the slope of the dam. The location of this point will depend somewhat on the elevation of the ground-water table. Under this condition the dam would have ample security.

The total maximum rate of seepage through the model dam—Type I—under a head of 85 inches of water was at the rate of 117 gallons per twenty-four hours, or

$$\frac{117}{7.48 \times 24 \times 60 \times 60 \times 6.08} = 0.00003 \text{ cu. ft. per sec. per lin. ft. of dam.}$$

Under a head of 45 inches of water, the total seepage was at the rate of 37 gallons in twenty-four hours, or

$$\frac{37}{7.48 \times 24 \times 60 \times 60 \times 6.08} = 0.000009 \text{ cu. ft. per sec. per lin. ft. of dam.}$$

The head in the second case is but little more than one-half that in the first. The areas exposed to the water pressure also vary in about the same proportion. The slope of saturation in the first case is about double that in the second. From the above it appears in the second case, if the area exposed had been one-half and the pressure applied one-half of that used in the first case, the flow would have been about

one-quarter, if the slope lines could have been continued to the base line in each case. The conditions then would be comparable. To compare results, refer to Plate 139.

CASE I.—*Forty-five-inch head.*

AC = 2.79	Pressure on AB = AC − $\frac{1}{2}$ AB = 2.50
AB = 0.58	Pressure on BC = $\frac{1}{2}$ BC = 1.10
CB = 2.21	Using unit areas horizontally.
BD = AS = 65.0	(*a*) Area AB = AB = 0.58 square feet.
AE = 82	(*b*) Area BC = BC = 2.21 square feet.

To reduce these to an equivalent area having a slope $\frac{p}{1} = \frac{2.21}{65} = 1:29.4$

(*b*) is already in this condition.

$$(a)\ \frac{p}{1} = \frac{2.50}{65} = 1:26$$

The discharge per unit varies as the slope, therefore to reduce (*a*) to (*b*)

$$\text{unit area } (a) : \text{unit area } (b) :: \frac{1}{26} : \frac{1}{29.4}$$

$$\text{Multiply unit area } (a) \times \frac{29.4}{26} = 1.13$$

(*a*) 0.58 × 1.13 = 0.66
(*b*) 2.21 × 1.00 = 2.21

2.87 = Equivalent area under slope 1:29.4

Also, if the slope had extended to E, as the slopes are equal, the discharge would vary as the areas, therefore in the ratio $\frac{2.79}{2.87} = 0.97$, or the discharge at E would be 0.97 × that observed at S.

CASE II.—*Eighty-five-inch head.*

FP = 5.54	Pressure on FG = FP − $\frac{1}{2}$ FG = 4.75
FG = 1.58	Pressure on GP = $\frac{1}{2}$ GP = 1.98
GP = 3.96	Using unit areas horizontally.
GK = 56.0	(*a*) Area GP = 3.96 square feet.
FM = 78.4	(*b*) Area GF = 1.58 square feet.

To reduce these to an equivalent area having a slope $\frac{p}{1} = \frac{3.96}{56} = 1:14.1$

(*b*) is already in this condition.

$$(a)\ \frac{p}{1} = \frac{GF}{KG} = \frac{4.75}{56.0} = 1:11.8$$

$$(a) : (b) :: \frac{1}{11.8} : \frac{1}{14.1} = \frac{14.1}{11.8} = 1.20$$

(*a*) = 1.58 × 1.20 = 1.89
(*b*) = 3.96 × 1.00 = 3.96

5.85 = Equivalent area under slope of 1:14.1

Also, if the slopes had extended to "M," as the slopes are equal, the discharge would vary as the areas, therefore in the ratio $\frac{5.54}{5.85}=0.95$, or the discharge at M would be $0.95 \times$ that obtained at S.

Comparing now the above discharges and slope

$$\text{Case I.—}q=0.97 \times \text{discharge at S.}$$
$$\text{Slope}=1:29.4$$

$$\text{Case II.—}q=0.95 \times \text{discharge at S}$$
$$\text{Slope}=1:14.1$$

Discharges under the same pressure through unit area vary inversely as the lengths. Thus, unit area I : unit area II :: $\frac{1}{29.4}:\frac{1}{14.1}$, or in the ratio $\frac{14.1}{29.4}=\frac{1}{2.08}$; that is, the discharge per unit area of II is 2.08 times that of I. The areas of II and I vary as $\frac{5.85}{2.87}=2.04$. Then the discharge of II should be $2.04 \times 2.08=4.24$ that of I. The increased discharge of I may be due to two causes: One, the water stops on the bottom which affect the area in I in greater degree than in II; and the other, to the coarse material that was washed from the rear end of the tank and deposited in the front end just after the unstable material mentioned above was washed out, which would also have greater effect on I than on II. On this account it appears that it would have been better to have washed out all of the material at this time and started afresh with construction. If this had been done the slope line would undoubtedly have been nearer a regular curve slightly concave upward, and the probability is that the discharge in both I and II would have been reduced. A comparison of the outlines of the proposed dam and the model dam and reference to the slope of saturation shown in the model indicates that if the proposed dam were constructed by methods similar to those employed in model dam type I, but with a 3:1 slope on the downstream side extending to the base, the leakage would probably be proportional to that actually found in model type I.

The Gatun dam has been estimated to be about 1½ miles long, but this length refers to the crest line, which is 50 feet above the high-water line. In the main this dam follows ridges of hills in which the solid rock either outcrops or comes nearly to the surface. The dam is spoken of as being 135 feet high and exposed to 85 feet of water, but this is only in the maximum section, where it crosses the valleys. Taken between the rock in the hillsides and excluding the masonry dam in the spillway, the actual length of the dam and the pressure against it are shown in the following table:

TABLE 9.—*Head on dam.*

Water.	Pressure.	Length exposed.	Water.	Pressure.	Length exposed.
	Lbs. per sq. in.	*Feet.*		*Lbs. per sq. in.*	*Feet.*
0 feet (high water, +85')	....	5,100	50 feet	21.65	4,100
10 feet	4.33	5,000	60 feet	25.98	2,700
20 feet	8.46	4,800	70 feet	30.31	2,000
30 feet	12.99	4,600	80 feet	34.64	1,600
40 feet	17.32	4,300	85 feet (sea level)	36.81	500

The seepage in the model dam (Type I) was at the rate of 0.00003 cubic foot per second per linear foot of dam. As the discharge varies as the areas under similar conditions, in the actual dam this seepage would be at the rate of 0.00036 cubic foot per second per linear foot of dam of maximum section. If, now, the rock ridge in the hills were just as permeable as the built-up dam under the entire crest line, the seepage would be $0.00036 \times 5{,}100 = 1.84$ cubic feet, or 13.77 gallons, per second, and equivalent to about 5½ ordinary water pails full per second. This, however, is a condition based on a discharge if the dam were cut off at a point where the 3 on 1 upper slope on the downstream side would intersect the base, and, under probable conditions, this would be reduced somewhat. If the rocks in the hills are also considered impermeable the seepage would probably be reduced about 25 per cent. The total seepage therefore might be about 10 gallons per second. A safe estimate therefore is 12 gallons, or 1.6 cubic feet, per second.

Below sea level the area in the gorges is about 384,000 square feet. This whole area, no matter what its depth, is, of course, exposed only to the pressure due to 85 feet of water, and the length through which the water would have to percolate could be not less than the length of the hydraulic-fill portion on the natural surface, say about 1,200 linear feet. Neglecting now the frictional loss in forcing its way through the surface, and considering that the water pressure is applied directly to a perpendicular face immediately under the upstream toe, and a discharge through a similarly perpendicular face 1,200 feet north under the downstream toe, we have 85 feet of water applied to a section having an area of 384,000 square feet and a thickness of 1,200 feet. This gives a hydraulic grade $\frac{h}{l} = \frac{85}{1{,}200} = \frac{1}{14}$, which, it will be noted, is about the same as that found for the conditions under 85 inches head.

Assuming that the discharge was 0.00003 cubic foot per second per unit width, an assumption entirely on the safe side, the height of the unit area is 5.54 square feet, and therefore the discharge per square foot $= \frac{0.00003}{5.54} = 0.0000054$ cubic foot per second. On this basis the total discharge under the dam would be $384{,}000 \times 0.0000054 = 2.14$ cubic feet per second for the cross section below sea level. Dividing this amount by the area below sea level and the porosity (say, about 0.36), and bearing in mind that 0.25 foot per second is said to be the velocity of current that will move clay, a figure is arrived at that seems to offer a reasonable factor of safety. Even if there were some coarser streaks that would let water through at a faster rate, there seems to be sufficient leeway on the side of safety.

	Cubic feet per second.
Above sea level	1.60
Below sea level	2.14
Total	3.74

$86{,}400 \times 3.74 = 323{,}200$ cubic feet per day, or about 2,500,000 gallons per day. This is on the basis that the entire valleys below sea level are porous and permeable, which is not the case. As the results of experiments at Clinton, Mass., Mr. F. P. Stearns[a] gives the follow-

[a] Trans. Am. Soc. C. E., Vol. XLVIII, p. 270.

ing table, columns 2 and 4 being added for the purposes of this discussion:

TABLE 10.—*Amounts of filtration in gallons per day through an area of 10,000 square feet of different materials with a loss of head of 1 foot in 10.*

[Figures reduced to a loss of head of 1 in 14 are given in the last column.]

Material.	Relative permeability. Soil = 1.	Loss of head. 1:10.	Loss of head. 1:14.
Coarse sand	4,320	2,200,000	1,570,000
Medium sand	785	400,000	285,000
Fine sand	176	90,000	64,400
Very fine sand	14	7,200	5,100
Soil	1	510	360

$\frac{2,500,000}{700,000}$ = 35,700 gallons per 10,000 square feet area in the actual dam. This, it will be observed, is somewhat less than for "fine sand" given in the table above. If, therefore, the entire superstructure and foundation were composed of fine sand, there might be expected the seepage estimated. The projected area of the dam above sea level is about 316,000 square feet. The analyses of the materials pumped into experimental dam (see Table 7) show that the effective size of the materials there corresponded to the designation of "fine sand." The seepage investigations seem to show that the materials in the foundation are similar to those in the experimental dam.

Investigations of the conditions in the hills and valleys and in experimental dam, Type I, also giving consideration to the sheet piling to be driven across the gorges, and the reduction of seepage that will probably be shown in experimental dam, Type II, seem to show that 2,000,000 gallons, or about 270,000 cubic feet per day, is an ample amount to cover leakage at the Gatun dam. This amount is based on all the material in the foundation being as permeable as that found in the experimental dams. As shown by the analyses, the conditions give a very much exaggerated effective size and, therefore, discharge. Based on that determination, the seepage through the foundation would probably be not more than 5 per cent of that given above.

PRACTICAL EXPLORATION METHODS AND RESULTS.

The site of the proposed dam at Gatun has been thoroughly explored. The results of this work are here set forth, and all the samples are on file and subject to inspection. As a part of this discussion, there are attached the records of the individual bore holes. In the following description it is not intended to go into detail, but to consider the exploration as a whole and bring out salient points and special features that appear to show the general condition of the materials that will underlie the proposed Gatun dam.

TEST PITS.

The most complete information regarding underground conditions is obtained by test pits. As the surface layer of soil is usually weathered and more or less disintegrated by vegetation, it is cus-

tomary in earth-dam building to remove this portion. For this purpose a number of shallow test pits were dug, and from the information thus secured it appears that solid ground may be had by stripping the area under the proposed dam to a depth of from 1½ to 3 feet, depending on the location. Besides the above, two deep test pits have been dug. One is in the head of the spillway and is through solid rock to an elevation of -33.5. This pit was 10 feet square and has a total depth of 80 feet. The geological formation passed through is shown on Plate 140. The strata passed through was typical of that encountered in excavation and drilling, both in the spillway and lock site. They were firm enough to keep the sides of the pit vertical for the entire depth, with only a few stay braces to keep pieces on the sides from falling down. All of the strata encountered seemed badly seamed, and through these seams came large quantities of water. This water seemed to come mostly from the upper portions of the formation, but reached a level at about grade $+7$ or $+8$. It greatly increased as the rains became more frequent until it reached an inflow of about 60,000 to 80,000 gallons per day. As the hill is practically cut off by the surrounding river gorges, and as the water was observed to be following down the excavation through cracks and joints, it was apparent that the flow was coming from local sources and that the elevation of the permanent ground water was at about this height. The rock strata dips northerly from this point, and bore holes in the spillway were affected slowly by the rise or fall of water in this pit, due to the stopping of pumping.

The materials found were of varying degrees of hardness. All could be excavated by pick, but this process would have made progress very slow. Churn drilling by hand was resorted to, the holes were quickly put down, and then the material broken up by blasting. Some of the material, the conglomerate and some of the coarser sandstone, although hard and firm in place rapidly disintegrated when exposed to air, and became, after a short exposure, similar to sand and gravel. Observations in the pit itself and from permeability tests made in the laboratory showed that all of the rock encountered in this pit was practically impervious in itself. The water comes almost exclusively from the joints in the formation. The layer of conglomerate between elevation -1.4 and -23.2 seems to be the reservoir for the water that is encountered in this location. Although not able to be demonstrated beyond question in this test pit, yet from evidence here and in the diamond-drill holes, it seems probable that the bulk of the water is held in the disintegrated portions of this strata, and has passage along the joints from one plane to another more or less freely. (Plate 136, fig. 1). In the test pit, and in the majority of the drill holes, this layer is compact and impervious in itself. In the test pit there was a hole uncovered 6 inches in diameter and reaching 10 or 12 feet into the side of the hill in this formation. A great part of the water poured from this hole, which some material found in it showed was undoubtedly left by the decaying of a log of wood. Besides the water due to the rains, the most noticeable increase has come since the blasting has been nearing the pit. This has undoubtedly opened up joint planes that have let in this free flow of water. This action of the blasting should be taken into consideration when the masonry of the spillway is put in.

At a distance of from 40 to 50 feet below sea level is a layer of rhyolite, apparently forming a firm and solid stratum. A curtain wall let down to this layer would undoubtedly furnish ample protection against any entrance of water from the lake to the seams and cracks. At the upper end of the spillway the diamond drills encountered a layer of what appeared to be clay and gravel, but farther north on the axis solid rock was excavated which gave complete cores. This layer was probably the layer of conglomerate found in the test pit and mentioned above, which had become disintegrated by weathering when anciently exposed on the hillside at the time when the river was cutting the deep gorges. It weathered back for a short distance and then the rock became sound.

The second pit is on Gatun Island on the center line of the dam and about halfway between the present Chagres bed and the French canal. This pit was laid out at the top 20 feet square, and the bottom has now reached elevation – 80 or 90 feet below the surface of the ground. The geological structure of the materials is shown in Plate 141. Very little water comparatively has been encountered. Until its limit of hoist was reached, a small pulsometer working intermittently took care of all the water. Since that time a boiler-feed pump has been used, and the measured flow has been at the rate of 20,000 to 25,000 gallons per day. Daily measurements have been kept, but there has been no noticeable variation since leaving the layer of blue sandy clay near the surface. It seems that all the water is coming from this location, either through or behind the sheet piling. Plates 70 and 71 show this pit under construction. Plate 70 shows a general view of the surface conditions at the mouth of this pit. When taken, the bottom of the pit was at elevation – 50, and on August 25 it was at elevation – 78, the steel sheet piling having been successfully driven and no difficulties being encountered in the excavation. Plate 71 is a view of the pit showing the method of bracing. A 40-foot steel sheet pile is hanging on the chain and is ready to be put into the pit. Driving leads shown to the left. This pile is one of the set being driven in the bottom of the pit, and when in place their points will be at a distance of 90 feet below sea level. Twelve piles had already been driven when this view was taken.

The first 30 feet of the pit was sheeted with ordinary wooden timbering, and the remaining 70 feet was protected with interlocking steel sheet piling. All of the bracing was octagonal, thus leaving a clear open space in the center. The description of the materials passed through is given later in the general description of the materials found in the valley. No settlements of any kind have occurred, and there has not been the slightest tendency at any time for the bottom to rise up. When the bottom of the first set of steel sheet piling was reached, the excavation was 65 feet below the surface, in the layer of clay and shells. This layer was so solid and impermeable that every shovelful had to be picked with difficulty. On the sides next the sheeting, the material only a few inches in thickness stood upright for 3 or 4 feet, although water was trickling down over it. The layer was so compact that the bottoms of the sheet piles were sprung out, leaving at this depth openings between them in places 6 to 8 inches, and in other places it had been impossible to drive some of the piles way down. When it is remembered that the pile driver seen (Plate 71) was continually driving steel piling in this pit, and

that the openings spoken of above were unprotected during the work, the condition of the ground for 70 feet below the surface can be realized. So far as can be judged by careful study of the numerous samples from the bore holes in this vicinity, and comparing them with the conditions visible in the test pit, it appears that the entire location across the gorges is composed of materials not radically differing from those exposed here.

KEYSTONE DRILLS.

On Plate 72 is shown the keystone drill at work. The samples are taken by dropping the heavy steel barrel which the man in the center is holding, and working it up and down in the hole until the sample is driven into the barrel. The barrel is then raised and the sample forced out. In the foreground are some of the samples, the largest shown being 18 inches long. Plate 73 shows full-size cores from this drill. The one on the left is clay with some rotten wood, but the sample is compact and impervious. On the left is the blue sandy clay forming the strata through which it is proposed to drive sheet piling. As this material contains some water and covers a more or less extensive area, it is proposed to take every precaution.

Except the test pits, this machine has given the best information regarding the materials underground. It was first located about 200 feet east of the test pit. The samples taken with this drill are about 2½ inches in diameter, and a continuous drive sample has been taken from the surface. Almost no waiting has been done except to lower the casing through the layer of sandy clay. Therefore a perfectly representative section of the valley deposit is available for study.

WASH DRILLING.

Classification of samples.—Wherever possible drive samples have been taken of all the materials passed through, and no pains or time have been spared to accomplish this result. This was done because it was felt that only by this means could accurate knowledge of the actual condition of the materials below the ground be obtained. The wisdom of this method is made apparent by examining Plates 74 and 75. These are views of two samples taken at similar elevations at the bottom of the gorge, and show full sized and very plainly the character of the material here and its properties as a freely water-bearing medium. In the center of each photograph are the "drive" or "dry" samples taken in place by the core barrel. Outside of them, toward the margin, the piles of sand and gravel show the characteristics of this material as obtained from wash samples. The samples were obtained by washing out portions of the "dry" samples near by. The result is material similar in every way to the "wash" samples of these and other holes. The samples from these holes are exactly similar to those taken from hole 1054, which is in the immediate vicinity. In neither of these holes was there any difficulty from water, although some was found in the holes. Hole 1054 was flowing because the casing was at a lower elevation. A hole not far from these, and on the center line near the test pit, had similar material in its bottom, and it was possible to bale this hole 100 feet with an ordinary 1½-inch pipe with a flat valve in the bottom. The views

of the dry samples are ample evidence of the imperviousness of this material and its inability to allow the passage of water.

At various times on this work there have been from 12 to 15 different foremen, and these of all stages of competency and familiarity with the work. The majority, however, were experienced men, and a few had made the original borings here and were familiar with the conditions found heretofore. This was the case among others of the outside supervisor on this work and was a great advantage. Early in the work it was found that the original foremen's notes taken in the field were misleading. Different men had different classifications for the same material. Oftentimes one foreman lacking skill was unable to get drive samples from deep holes and reported soft water-bearing strata. Another man would go down nearby and get dry samples. Varying with the pressure of the water used in drilling and the amount used, similar material would show entirely different characteristics. In the clay and rotten wood layers, one hole would be driven through a stump or log, and the material soft with water when washed up would be classed as mud. The test pit and keystone drill did considerable to straighten out this matter.

It seemed that the best results, however, could be obtained as follows: When the samples came in, accompanied by the foreman's record, they were carefully looked over as soon as possible and compared with the foreman's classification. One man was practically continuously employed on this work, and he soon became expert enough to readily classify materials from all of the parties, so that, while not deviating from the foreman's report, samples of similar material would be given the same classification. Minute differences as to color, condition of material, etc., were noted when they occurred. These determinations appear in detail on the separate sheets of the holes.

When the time came for making this report, all the samples were again gone over independent of the original records, and materials differing only in minor matters were grouped under a general classification. After they had been so grouped, they were checked by reference to the original records. In this way, it is felt that the nearest approach is made to the actual manner in which the materials are laid down in the valley. An example of this classification is shown in the record of Hole 1094. (Plate 142.)

On Plate 76 is shown a wash drill gang at work. In the foreground are the lengths of "drive" rods to be screwed together and lowered into the hole. Back of these are 2½-inch "casing" pipe which is driven down the hole to protect it from filling if the materials passed through are loose and unconsolidated. In working this drill, water under pressure is admitted to the hollow drive pipe through a swivel near the hook on the lower block. The men on the rope now jerk the pipe up and down, and the water, passing down inside the rods, washes out the material at the bottom. As the water rises in the casing outside the drill rod, it brings up the materials encountered in the hole, and these are caught as "wash" samples. The water rising can be seen near the top of the pipe. It can be readily understood that the samples obtained in this manner are thoroughly washed and cleaned, and that only the coarser parts are easily caught. Except by judgment, no reliable knowledge of the materials is secured in this way. Oftentimes materials have been classified as

gravel or sand by an ignorant, or what is worse, an indolent foreman, when, in reality, they were of such material as is shown in the cores of Plates 74 and 75. "Drive" samples are taken with this rig by shutting off the water, and using a sample barrel which is driven down into the material and a sample taken of the formation in place. These samples are the most to be depended upon in forming an opinion of the materials in the ground. When 150 to 250 feet of heavy rods are down in a hole, the need of the men here shown is apparent.

GENERAL DESCRIPTION OF THE MATERIALS.

The material under the entire site from the surface down to the rock may be generally classified as clay with some sand. It ranges from 97 per cent clay to 11 per cent clay, being mixed with sand, shells, and decayed vegetation, and has been classified under 7 subdivisions: 1, red clay; 2, brown sandy clay; 3, blue sandy clay; 4, blue clay and rotten wood; 5, blue clay and shells; 6, stiff blue clay; 7, clay, sand, and gravel.

1. Red clay.—This clay is formed from decayed rock, and is found overlying the rock on the spillway hill and the hill beyond the west diversion. The base of this material is clay with a mixture of sand and decomposed rock.

2. Brown sandy clay.—This clay is an alluvial deposit, and is found at the surface of the old gorges. It is composed of about 50 per cent each of clay and sand, the sand grading from medium to superfine.

3. Blue sandy clay.—An alluvial deposit in the old gorges usually underlying the brown sandy clay. While its base is clay, it has a sandy appearance because the sand it contains grades from coarse to very fine. This is the most permeable material which has any considerable extent.

4. Blue clay and rotten wood.—An alluvial deposit in the old gorges, a large percentage of which is blue clay. In this material is found a fine sand and decayed vegetation, the latter occurring in pockets, and, when present in large proportion, giving the clay a dark color.

5. Clay and shells.—An alluvial deposit of blue clay and sea shells, the larger percentage of which is clay and the remaining portion composed of shells and sand. The shells occur in pockets, and the maximum proportion found was 48 per cent of shells by weight, or 30 per cent by volume.

6. Stiff blue clay.—An alluvial deposit of almost pure clay usually found just above the rock in the old gorges. It is very stiff and compact, and gradually grades into argillaceous sandstone.

7. Clay, sand, and gravel.—An alluvial and wash deposit containing small, angular fragments of hard rock found in the bottom of the old gorges, usually overlying the rock. It is found in pockets, which, while somewhat extensive, do not extend in a continuous layer under the dam. In places it is compact and impervious to water, easily breaks down in a stream, and the wash samples show a very coarse gravel. (Plates 74 and 75.)

MECHANICAL ANALYSIS.

Mechanical analyses were made of the various materials, using from 2 to 12 samples of each, selected from various localities, and an average analysis of each material was determined from these analyses.

Drive samples only were used, and the true condition of the materials as they are in place is expressed. Plates 143–147 show typical bore holes. Plates 148–154 show mechanical analysis curves.

Four profiles were made from borings—one on the dam axis, the others parallel thereto, one 400 feet north, one 300 feet south, and the fourth at the north toe. From the first three the area of the average section of each material was determined. (Plates 155, 156, and 157.)

Five cross sections through the gorge under Gatun Island at right angles to the dam axis (Plates 158, 159, 160, 161, and 162), one cross section longitudinally through the spillway (Plate 163), and one cross section through the west diversion (Plate 164) show conditions in these localities. Taking the area shown in the profiles and using Hazen's formula for determining the velocity of water through sand, the quantity that would percolate under the dam in twenty-four hours was determined. This quantity was determined under two conditions: (1) Dam without sheet piling and (2) dam with sheet piling across Gatun Island extending below the blue sandy clay, the maximum depth being −75 and across the west diversion extending to −50. While this west diversion gorge is deeper, the deposits seem very firm and resistant to the free flow of water, and the coarse pockets found under Gatun Island do not appear in the borings. The formula used was $v=\left(\frac{h}{1}\times\frac{t+10}{60}\right)$ in which

v=velocity in meters per day of twenty-four hours.
c=constant quantity; 500 was used, as the materials contain much clay, and the average uniformity coefficient is high.
d=effective size in millimeters.
h=head; 85 feet, the maximum head of the lake, was used.
i=length; 1,200 feet was used. This is the total length of the hydraulicked portion of the dam at sea level.
t=temperature in degrees F.=85° F.

The following results were obtained:

TABLE 11.—*Dam without sheet piling.*

Material.	Average area of section.[a]	Seepage per 24 hours.	Velocity per 24 hours [b]	Average effective size.	Average uniformity coefficient.	Average clay and silt.
	Square feet.	*Cubic feet.*	*Feet.*			*Per cent.*
Red clay	177,000	1,970	0.0111	0.008	4.1	73.6
Brown sandy clay	35,000	1,755	.0502	.017	6.0	46.0
Blue sandy clay	130,840	7,370	.0564	.018	5.5	60.6
Blue clay and rotten wood	44,100	495	.0112	.008	5.5	76.4
Clay and shells	42,700	365	.0085	.007	4.3	84.1
Stiff blue clay	119,350	1,165	.0098	.0075	4.1	89.6
Clay, sand, and gravel	24,100	1,850	.0768	.021	22.1	33.5
Total	573,090	14,970	.0262	.0112	....	71.6

[a] This is the average cross section of a strip 700 feet wide under the highest portion of the dam section and extending from Lock Site Hill to the high hills west of the West Diversion.

[b] The velocity here shown is that in the entire cross section of the material. The actual velocity of the water will be probably from 2½ to 3 times that given, depending on the porosity and permeability of the materials.

TABLE 12.—*Dam with piling across Gatun Island and West Diversion.*

Material.	Average area of section.[a]	Seepage per 24 hours.	Velocity per 24 hours.[b]	Average effective size.	Average uniformity coefficient.	Average clay and silt.
	Square feet.	*Cubic feet.*	*Feet.*			*Per cent.*
Red clay	177,[illegible]	[illegible]	0.0122	0.0[illegible]	4.1	[illegible]
Brown sandy clay	-----	-----	-----	-----	-----	-----
Blue sandy clay	30,790	996	.0250	.012	5.6	64.8
Blue clay and rotten wood	22,220	[illegible]	.0112	[illegible]	5.5	78.4
Clay and shells	42,[illegible]	[illegible]	[illegible]	[illegible]	4.3	94.1
Soft blue clay	[illegible]	[illegible]	[illegible]	[illegible]	22.1	[illegible]
Clay, sand, and gravel	34,[illegible]	[illegible]	[illegible]	[illegible]	22.1	33.5
Total	[illegible]	6,[illegible]	.0155	[illegible]	5.3	78.2

[a] This is the average cross section of a strip 700 feet wide under the highest portion of the dam section and extending from Lock site to the high hills west of the West Diversion.

[b] The velocity here shown is that in the entire cross section of the material. The actual velocity of the water will be probably from 2½ to 3 times that given, depending on the porosity and permeability of the materials.

The averages at the bottoms of columns 4 to 7, inclusive, mean little, and are of use only for comparative purposes. For as a chain is only as strong as its weakest link, so a sand bank is only as impermeable as its coarsest portion. In this case, however, the coarsest portion has many conditions in its favor for offering resistance to flow of water, even if it did not show a seepage which, although large by comparison, is yet much too small to cause anxiety of any kind. In his paper on the Bohio dam,* the late Mr. Geo. S. Morison, an engineer, whose judgment on foundations was of the best, discusses the matter. After making various assumptions which, in the light of the borings made at Bohio, were very conservative, he uses such a condition that the value of *d* was taken at 1 mm., *c* at 1,000, and 1 at 2,500. The conclusion arrived at was that the velocity of the percolating water would be at the rate of 0.002 foot per second, or 173 feet per twenty-four hours, and the quantity for the whole area of permeable material would be 40 cubic feet per second. The permeable area in the Bohio dam foundation (20,000 square feet) was about that which is called "clay, sand, and gravel" in the Gatun gorges. The layer here is much less coarse than that at Bohio, and probably contains a much larger percentage of clay. Concerning this calculation, which he considered to err much too greatly on the side of safety, he makes the following statement: "The speed at which 40 cubic feet per second would issue from a surface equal to the cross section of the permeable material is 0.002 foot per second. The rate at which it travels through the voids in the sand, however, is very much greater, but would not exceed 0.008 foot per second. While a large aggregate of water can travel through a large section of sand at this low speed, the speed is not enough to move any material, except on an open exposed face of a comparatively steep slope. As the outlet, if any exists, is considerably below tide level, such disturbance is impossible."

As the velocities given in the tables here are feet per twenty-four hours, Mr. Morison's statement concerning the liability of damage by percolating water seems to apply with even greater force to this condition at Gatun.

* Trans. Am. Soc. C. E., Vol. XLVIII, p. 256.

In estimating the seepage through the clay and shells, the analysis of the clay portion alone was used, as the power of a material to transmit water is said to be decreased if larger particles are added, until 30 per cent of the mass is composed of the larger particles, and, as the largest percentage of shells by volume was 30 per cent, the quantity is larger than it actually should be.

DIAMOND DRILLING.

Wherever material thought hard enough to core was found, a diamond drill was introduced and samples obtained. Plate 77 shows a diamond drill at work. This machine consists of a solid iron framework, on which is set the gearing moved by the handles. Into this gear are keyed steel rods jointed in 5 or 10 foot lengths with threaded ends, and on the end of the rod a drill carrying a circular bit in which are embedded 6 or 8 black diamonds.

By means of the gear the bit is revolved in such a manner that the diamonds cut a round core similar to that shown in Plates 78 and 79. As this core is cut from the solid rock, it rises into a hollow tube called a "core barrel," and can be raised to the surface by lifting the rods. Those shown on Plates 78 and 79 are full size and indicate the appearance of the rocks in this locality. Plate 80 shows the action of the pebbles often found in sandstone and also the probable occurrence of a joint at the point. The cores are of solid rock, and experiments have proved that it is almost impervious to the flow of water. The slant of the sample to the extreme right is probably due to joint action. The drill catches in this joint plane, tears out a pebble from the mass, and then proceeds to use this pebble to grind up the core. The result is that rounded pebbles due to such a cause may be recorded as from a loose gravel streak carrying quantities of water, when in reality the rock is solid and impervious except where rent by the joint where water is pressing for an outlet. Plate 81 shows the method of filing and preserving the samples. The general character of the rocks passed through is shown on Plates 82 and 83. Plate 82 shows samples of the rhyolite and conglomerate. The rhyolite is the most impervious of the rocks found at Gatun, and does not readily yield to disintegration. Depending on the quality of the cementing material, the conglomerates are solid and enduring, or shaky, and crumble on exposure to the atmosphere. These rocks as a rule weather badly, and soon crumble to gravel when excavated. In place and thoroughly protected from the atmosphere they are solid. Like gravel, when they disintegrate they furnish a free passage for water. On the left of Plate 83 is a full-size sample of an ordinary formation. The dark bands are argillaceous sandstone and the light ones, alternating with them, volcanic tuffa. To the right is a sample of clay and shells as it comes from elevation −50 in the Gatun Island test pit. This material is solid and impervious. It stands vertically in the sides of the test pit and is not eroded by water flowing over it. An analysis shows that it is composed by volume of 70 per cent clay and 30 per cent shells.

SPECIAL FEATURES.

(a) *Rock in Spillway Hill.*—On Plate 84 is shown a general view of the Gatun spillway looking south or toward the proposed lake. In the background are noted two diamond-drill outfits, one with and the other without a rain shield. The outfit with the rain shield is located on the dam center line and a little east of the spillway axis. The sides of the excavation are evidence of the extent of the underlying rock in the hill, and the cores which have been taken from the drill workings 150 feet below the present location of the drills are evidence of the solidity of the foundation. Plate 163 shows a longitudinal geological section of this location taken on the center line of the spillway excavation.

(b) *Underground water.*—Heretofore much has been stated and huge fabrics have been constructed, based on the occurrence of water under pressure (commonly known as artesian water) in this locality. When this site was seriously considered 37 wash-drill holes were put down for the purpose of preliminary studies. Although the small number of these holes was sharply criticized as inadequate for proper determination of a dam site, they were found, nevertheless, to be of sufficient value on which to base a most alarming tale. Water was then found in some of the bore holes; in others it overflowed the casing to a slight degree, the maximum recorded being about 1¼ inches. No one questioned the presence of this underground flow then, and in the subsequent investigations that have been made the same condition has been found. Artesian flows have been found that rival those previously given.

A careful study of the conditions of this water, however, seems to show no grounds for alarm as to the safety of a dam erected on this site similar to that proposed if proper precautions are taken to safeguard its stability. These precautions are not by any means unique for this location, and are only those ordinarily taken by engineers familiar with the principles of earth-dam construction and the handling of water under pressure.

On Tables 13 and 14 is shown the height of the hydrostatic head in some of the bore holes. Whether or not there was flow depended on the height of the top of the casing. These holes may not be all in which such conditions were discovered, but only a few, if any, have been omitted, and those not by any design. If there was a continuous flow through the gorges of the quantity suggested, the current must have had such a velocity that a considerable loss of head would be evident, and it would show in a uniform manner, regularly decreasing in the direction of the flow. No such condition appears here; there seems to be no general scheme. Observing the holes at the base of the hills, it appears that here are generally found the highest heads, and those holes farthest away show the lower elevation of the water table. In contiguous holes there are differences of elevation of 8 or 10 feet. In neighboring overflowing holes there are great variations in quantity. It therefore appears from surface conditions that there could not be a single source for this pressure water. An examination of the materials taken from the bore holes, one of which contains water and the other none, shows similar material. In other holes the condition is reversed, and entirely different strata appear to produce water,

some from zones that the samples would indicate to be impervious. An examination of the underlying strata fails to find not only a continuous layer that could be water bearing, but also none at all of such a character that it could be freely water bearing. A glance at the mechanical analyses of the materials found in these bore holes is sufficient to indicate their permeability.

If the rock contour map shown as Plate 165 is studied in connection with the geological sections at right angles to the dam axis, and also the three typical sections across the valley parallel with the dam axis, evidence will be obvious that the conditions are not those tending to promote free underground flow.

There is water there, however, and it has a source at some elevation much greater than could be given by any current flowing underground. Such heads as here given, if due to water running in a stream underground even from Bohio, would demand an initial head out of all proportion to any elevation found hereabouts. In other words, neither at Bohio nor Gamboa is there sufficient elevation in the valley of the Chagres River to force an appreciable body of water through the alluvial deposits to Gatun and give such heads as are there found. Again, heads similar to those at Gatun are found at Bohio, which would, if there were free connection, indicate a level hydraulic grade line. Such a condition as this could obtain only with very slight velocity. Such a flow as this, when it came to the narrows at Gatun, would have to move with such a tremendous velocity that it would tear out the underlying strata. The whole valley would have to be soaking with running water. But these conditions do not appear at all. The only explanation, therefore, seems to be that the head obtained in these bore holes is of local origin, and derives its source from the hills. It is known to be there, and the conditions are ripe for its delivery. At the surface of the rock are found the most pervious conditions. The rocks are seamed and jointed. Under these conditions the water is conducted to the bottom of the gorges. Here it stays under pressure, but with no movement of any account. When a bore hole approaches this film of water under high pressure, the material at the bottom is blown out, and a flow of water takes place, more or less constant, dependent on the source. In Plate 166 is shown the probable reason why water under pressure is sometimes encountered and at other times not found. This seems to be an explanation that accounts for the vagaries of head found in the area at the Gatun dam site. If this is so, proper precautions, as cut-off walls, etc., will be able to effectually control the flow and eliminate any danger from this source.

Artesian water has been found in the following holes with heads as indicated. In many cases natural gas has been found in connection with the water, and in some cases has been the cause of the peculiar action of the water. In some instances, notably holes Nos. 1054 and 997, the drill rods showed the action of the gas and were covered with a black scale.

TABLE 13.

[Elevations are all above mean sea level.]

Hole.	Elevation of water.	Remarks.	Hole.	Elevation of water.	Remarks.
	Feet.			*Feet.*	
840	21.6	Started at −84.	953	10.8	Started at −51.
848	4.3	Casing was not extended higher.	954	11.8	
			955	14.2	
849	3.6	Do.	958	13.6	
868	4.3	Started at −46.	997	10.4	Started at −211; gas.
905	8.1		1003	13.0	
906	6.2	Casing was not extended higher.	1010	11.0	Started at −115.
			1025	9.4	Started at −153.
		Between −114 and −124.	1041	7.3	
907	6.3	Casing was not extended higher.	1054	12.0	Started at −175; gas.
			1055	9.8	
908	7.3	Do.	1061	....	Started at −66; shut off at −119.
909	9.1	Do.	1064	[a]9.0	Escaped through cracks in rocks.
937	-47.2		1069	10.0	Shut off at −46.
938	43.7		1070	....	Started at −220.
946	11.4	Salty.	1089	....	Gas at −163 which threw water over casing at −13.
947	35.0	Water spurted over derrick; gas pressure.	1092	10.5	Started at −118.
	27.0		1096	2.0	Started at −68; shut off at −70.
	23.2		1099	9.6	Very slight flow.
949	8.8	Started at −135, salty.	1110	11.4	Salty.
950	9.0	Started at −44.	1115	4.5	
951	10.1				
952	11.0				

[a] About.

The following holes have maintained a constant water level in spite of efforts to bail them out with a pipe bucket operated by hand:

TABLE 14.

[Elevations are all above mean sea level.]

Hole.	Elevation of water	Hole.	Elevation of water	Hole.	Elevation of water.
	Feet.		*Feet.*		*Feet.*
802	7.7	914	1.8	1074	31.6
813	11.6	918	12.1	1083	5.5
814	11.6	920	63.5	1087	13.4
815	7.4	924	85.5	1091	2.5
868	3.8	960	20.9	1086	9.3
872	75.3	979	22.0	1114	5.2
887	12.8	982	23.2	1002	18.0
888	13.7	1000	22.8	1019	14.2
903	14.9	1073	9.1		

To the cause mentioned above is undoubtedly due the flow of water from a so-called spring on Gatun Island on the west bank of the Chagres, almost opposite what is known as the old office, and about 400 feet north of the center line of the dam. The water supplying this undoubtedly owes its head to the lock-site hill. Rising there, it flows through the sandy clay stratum under the bed of the Chagres and outflows on the west bank. That it does this instead of finding an outlet into the river itself is not strange, for its head is only a few feet above tide water, and the blanket of sediment in the bottom of the river, weighted by the water thereon, is probably

sufficient to effectually stop egress there. The flow here varies interestingly with the rainfall, as shown by the following results:

TABLE 15.

Date.	Time.	Rate of flow in 24 hours.	Remarks.
		Gallons.	
June 8	10.45 a. m	2,650	
8	1.45 p. m	2,186	
9	9.45 a. m	3,014	
10	8 a. m	3,301	
11	10 a. m	2,503	
13	9 a. m	2,165	
15	10.30 a. m	1,790	
16	8.45 a. m	1,978	
17	10.30 a. m	1,514	
20	8 a. m	9,600	
23	8.30 a. m	4,800	
24	2.40 p. m	28,800	2 hours after heavy rain.
24	5.10 p. m	16,070	
25	8.30 a. m	10,166	
25	2.30 p. m	115,200	15 minutes after heavy rain.
26	(?)	172,800	After 3 heavy rains.
27	9 a. m	28,800	
29	8.35 a. m	9,145	
30	10.20 a. m	69,306	
July 1	10.10 p. m	10,166	
3	8.30 a. m	11,162	
6	9 a. m	6,400	
7	9.40 a. m	7,200	
28	3.25 p. m	5,760	
30	9.10 a. m	12,528	
31	10.30 a. m	5,242	

(c). *Former classification.*—The present investigations have thrown new light on some of the former records, and conditions then indicated as suspicious, if not serious, for safety, can now be differently interpreted. One or two examples are sufficient to indicate this. In the west diversion, hole No. 519 was recorded as having gravel for about 100 feet. The ordinary man would be loath to found a dam on a loose gravel layer. An examination of the samples there taken indicates that the material was similar to that shown in Plates 74 and 75, and the analysis shows it to have an effective of about 0.02 millimeter, with about one-third clay. This does not appear as a very permeable material, and the velocity through it under the proposed conditions would be about 0.08 foot in twenty-four hours. Material that was formerly classed as packed sand has been found to give cores under the diamond drill. This shows rock, and rock, no matter if it is soft, is a much more stable material than an unconsolidated deposit.

The test pit on Spillway Hill has demonstrated this packed-sand material. It is thoroughly consolidated, but is easily cut with a knife. It appears impervious in place, and laboratory experiments show it to be so. It will crumble in the hand when shaken up by blasting or when exposed to the weather. On the other hand, it stands with vertical face in the sides of the pit. It does not crumble or disintegrate when exposed to the action of water running over it. It also has well-defined joint planes and seams through which water passes into the pit with velocity enough to throw the stream from 1 foot to 1½ feet into the opening. These joint planes are filled with mineral deposits, showing that they are of ancient origin and not

due to recent causes. As has been said above, however, the nearby blasting has opened up these planes, resulting in a very great increase in the water in the pit.

TABLE 18.—*Summary of boring.*

Drilled from December 1, 1907, to August 9, 1908:	Linear feet.
Wash drilling	26,222
Diamond drilling	3,413
Keystone drilling	398
Total	30,033

THEORETICAL CONSIDERATIONS.

Definitions.—The terms "permeability" and "porosity" are often used interchangeably, whereas they have entirely different significations. Two sands having the same porosity may be different entirely as to their permeability, and vice versa.

When the total amount of pore space is large, regardless of the size of the passageways, the material is porous. The relative freedom with which liquids or gases flow through a porous medium is the measure of its permeability. Water will freely pass through a sand having an effective size of 4 mm. and a porosity of 32 per cent—that is, about one-third of its volume open space—while a clay of 0.01 mm. effective size and 48 per cent porosity, or about one-half volume open space, will be practically impervious, although the proportion of voids in the two is in the ratio of 2 to 3. The experiments of King[a] and Schlicter give the most available data on pore space and kindred determinations. In dealing with spherical grains of uniform size, the pore space has been found to range from a minimum of 26 per cent to a maximum of 48 per cent of the total bulk. The results of experiments have shown that relatively sands of small grain have greater pore space than those of larger grain, even when equally tamped. The general summary of the determination is (*a*) while the pore space can be greatly decreased by tamping, it is rarely possible to reach the theoretical minimum; (*b*) equally treated sands with different diameters of grain have smaller pore spaces than those of uniform diameter; (*c*) angular sands have more pore space than rounded sands; (*d*) the least pore space may be expected when the grains are rounded and about equally divided between large and small, with no intermediate sizes. Therefore the permeability of a material depends upon the arrangement of the grains, their size, the proportion of the different sizes, and their shape.

The closer the grains are packed the less the permeability. Relatively, coarse angular sands are more permeable than fine rounded ones, as the individual spaces are larger.

The terms "effective size" and "uniformity coefficient" are those used by Hazen in his investigations. As a result, he concluded that "in mixed materials containing particles of various sizes, the water is forced to go around the larger particles and through the finer portions which occupy the intervening spaces, so that it is the finest portion which mainly determines the character of the sand for filtration."

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[a] Nineteenth Annual Report U. S. Geol. Surv., part II, pp. 209–215 and 306 et seq.

In comparatively coarse gravels the flow of water seems to obey the law governing flow through large pipes—that is, the quantity varies as the square root of the head—while in fine sands the discharge is directly proportional to the head, and similar to that in capillary tubes. In pipes there is a certain critical velocity where the law changes from capillary action to that in large pipes, and probably the same holds true for the action of water in passing through porous materials.

In statements concerning the water-bearing capacity of soils, the terms "percolation," "infiltration," "filtration," and "seepage" are often used erroneously.

"Filtration" is the process of mechanically removing undissolved matter from a liquid.

"Infiltration" is the process by which a liquid enters into a porous material.

"Percolation" is the action of a liquid in passing through small interstices.

"Seepage" is the amount of the liquid that has percolated through the liquid.

A water may be filtered to clarify it or remove objectionable matter. This water passes through the pores in the sand by the process of infiltration. The amount passing through in a given time is the seepage, and the ease with which it passes or percolates through the pore space is dependent upon the permeability of the material.

For the study of the flow of water through permeable materials, it is found most convenient to consider them as made up of grains of such size that the flow through the given material will be equivalent to that which would pass if the material were entirely composed of certain-sized grains. This size is called the "effective size" and its size for a given material is such that 10 per cent by weight of the material is finer than this size and 90 per cent coarser. Besides the effective size of the sand grain, an important point regarding the percolation of water is whether the particles in the material under consideration are of approximately the same size or are of varying sizes. This is shown by the "uniformity coefficient," which is used to designate the ratio of the size of grain which has 60 per cent finer than itself to the size that has 10 per cent finer (effective size).

"A rough estimate of the open space can be made from the 'uniformity coefficient.' Sharp-grained materials having uniformity coefficients below 2 have nearly 45 per cent open space as ordinarily packed, and sands having coefficients below 3 as they occur in banks or artificially settled in water will usually have 40 per cent open space. With more mixed materials, the closeness of the packing increases until with a uniformity coefficient of 6 to 8 only 30 per cent open space is obtained. With extremely high coefficients almost no open space is left."

In general, it may be said that the smaller the uniformity coefficient the greater the degree of voids in the material, but, as has been said, the permeability and not the amount of voids determines the freedom with which water flows through a sand or gravel, and this depends somewhat on the effective size and the shape of the grains.

In material of the same permeability, increasing the slope or "hydraulic gradient" increases the flow; that is, the velocity and the discharge are increased if the thickness of the material is decreased.

Likewise, with the same slope of saturation, increasing the permeability increases the flow. But the flow is decreased by decreasing the permeability, therefore to maintain the same flow if the permeability is decreased the gradient must be increased, which is the same as saying that the thickness of the material is decreased. It appears, therefore, that decreased permeability may be indicated by a steeper hydraulic gradient if the flow remains constant. As in pipes, in sand and gravel the hydraulic gradient indicates pressure, and insomuch as pressure indicates flow, velocity is dependent on the slope of the hydraulic gradient. In a homogeneous material and with the same amount of water flowing under the same head, the permeability and the velocity vary inversely as the length. For the same flow the more permeable the material the greater will be the length of the grade line and the less the angle of slope.

If the material is sufficiently permeable beyond the point where the hydraulic gradient would intercept the horizontal plane under conditions of free flow, the flow dependent upon the pressure indicated by the slope of the hydraulic gradient will run along this plane similar to water in an open channel. If there is friction here to be overcome, the slope $\frac{h}{l}$ will flatten till it has adjusted itself to the conditions imposed, depending principally on permeability. As it flattens to the outlet, however, the flow and velocity will decrease, and if the material is entirely homogeneous, the hydraulic gradient will be a straight line connecting the point of "no pressure" at the surface of the water in the reservoir and at the downstream outlet. This accords with the definition of "hydraulic gradient" given by Merriman. It can be illustrated by imagining a horizontal column of sand, its sides and bottom confined in a water-tight trough. If water is admitted at one end of the trough to the level of the top of the sand and the material is sufficiently permeable, a slope of saturation will appear in approximately a straight line connecting the surface of the water at one face and the bottom of the sand column at the other end. If, now, a board is put in at the downstream end and the water forced to find outlet over this, the sand will fill with water to the top of the board, and the hydraulic grade line will slope from this outlet to the water surface. The flow is now less than in the first case. If we keep on adding boards, we shall reach a point where the hydraulic grade line will be horizontal, and in this condition there will be no outflow, as the boards have reached above the level of the water surface, and the pressure on the sand will equal that due to the head of water; i. e., the pressure head plus the velocity head will equal the total head. But suppose the water in the trough, instead of being confined by porous sand, is held in place by a dense mass, as a plate of cast iron. In this case the hydraulic grade line is horizontal; there is pressure, but no flow, and the case is similar to that just stated.

By another definition the hydraulic gradient is a line joining the surface of the water in several vertical piezometer tubes which are placed along the pressure line. If the pressure line is vertical and there is no outlet, then piezometer tubes in this line brought up vertically will show a horizontal grade line. Suppose the cast-iron plate replaced by a very fine-grained stone. After a time there will be a little flow and a steep hydraulic grade line. If more permeable stone

is used, and later sand, the saturation slope will become more and more flat. The same amount of water is assumed to flow in all of the above premises. Plate 167 shows graphically the influence of size of grains and porosity in hydraulic grade line. The interpretation of this diagram is: If an embankment was built of material having a given effective size and porosity, and if its downstream slope cut the base line at the same point as the hydraulic grade line for that particular material, then the discharge would be 1 cubic foot per minute per linear foot of embankment. In the experimental dam it is shown that the hydraulic gradient does not start from the point where the surface of the water intersects the slope, but at a lower elevation. The difference in head is similar to the head lost in velocity and entrance in the case of water flowing from a reservoir through a pipe. It appears, therefore, that this "used head" will vary with the angle of the slope and the characteristics of the materials in front of the embankment, and that the pressure head can never equal the total head in the reservoir, and only approach it very nearly when the embankment has a vertical face.

With this action probably in mind, the board of experts appointed to examine the earth portion of the new Croton dam stated that "the more compact the material of which the bank is built the steeper will be the slope of saturation." There is undoubtedly a great difference between the slope of saturation when water is retained in an embankment and that taken by water in passing through material too permeable to retain it. In the latter case the condition is reversed, and the water will then take a path governed only by porosity, and the more open the material the steeper will be the slope. In this case the steeper the slope the greater will be the discharge.

METHODS OF DETERMINING POROSITY, EFFECTIVE SIZE, ETC.

Mechanical analyses.—The "effective size" of a material is determined in a number of ways. That most widely used is by passing the material through a number of sieves, and determining the proportion by weight of the material left on the several sieves. The apparatus generally used consists of a set of sieves ranging from 2 to 200 meshes to the inch. These sieves are about 8 inches in diameter, and so made that one sieve will fit tightly to the top of another. The material to be tested is thoroughly dried and put into the uppermost sieve and the whole set well shaken; the grains of different sizes are thus separated and left on the several sieves. These portions are then weighed and tabulated with respect to the total mass. The most convenient method of determination is to plot the results on cross-section paper, using the size of the sand grain for one coordinate and the total percentage that would be retained on the sieve as the other. The diameter of the sand grains is usually designated by the diameter of the largest particles passing through it instead of the commercial number of the sieve. The ordinary size of particles passing through the meshes corresponding to commercial sieve numbers for use in this report is given in Table No. 17.

TABLE 17.—*Sizes of sieves.*[a]

Stone series.		Sand series.		
Commercial sizes of sieves.	Diameters passing.	Commercial No. Meshes per inch.	Diameters passing.	Diameters passing.
Inches.	*Inches.*		*Inches.*	*Millimeters.*
2.25	2.25	10	0.075	1.91
1.50	1.50	15	.046	1.17
1.00	1.00	20	.034	.86
.75	.75	30	.020	.51
.60	.60	40	.016	.41
.45	.48	50	.014	.36
.35	.36	74	.0071	.180
.27	.29	100	.0058	.147
.20	.20	150	.0036	.092
.15	.16	200	.0027	.069
.10	.10			

For sizes of particles less in diameter than those passing through a No. 200 sieve, the method of elutriation described by Mr. Hazen[b] has been used.

[a] From Report of Experiments at Jerome Park Reservoir. "Laws of Proportioning Concrete," W. B. Fuller, p. 22.

[b] Annual Report, Massachusetts State Board of Health, 1892.

Typical analysis curves of the materials studied here at Gatun are shown on Plates 148–154. The effective size is found by drawing a horizontal line through 10 per cent marked on the vertical scale on the left of the diagram, and where this line cuts the curve directly under the horizontal scale is found the effective size. To find the uniformity coefficient, draw a similar horizontal line through 60 per cent on the left-hand scale, and take the size directly under the point where this line cuts the curve. Divide this latter size by the effective size, and the result is the uniformity coefficient.

DETERMINATION OF VOIDS.

The voids in sand or gravel can be approximated by placing a known quantity of the material in a measure, and pouring in water until it flushes to the surface. Then, by determining the amount of water poured in, the apparent porosity is known. This method, however, is liable to error on account of the physical impossibility of displacing all the air held in the interstices of the material. The most accurate method of void determination is by means of the specific gravity, and, if this is definitely known for the substances of which the sand and gravel is composed, the determination is easily made by the following formula:

$$\text{Percentage}^{a} \text{ of absolute voids} = \left(1 - \frac{S - Sp}{R}\right)100$$

S = weight of a cubic foot of the material.

R = weight of a cubic foot of absolutely solid rock of the same composition as the material.

p = percentage of moisture in material, determined by drying in oven at temperature of at least 212° F. until weight becomes constant.

If the per cent of air voids only is wanted, then this formula is to be used:

$$\text{Per cent of air voids} = \text{percentage of absolute voids} - \frac{Sp}{62.3}100.$$

[a] Taylor and Thompson, "Plain and Reinforced Concrete," p. 166.

TABLE 18.—*Average specific gravity of various aggregates.*

Material.	Specific gravity.	Weight of solid cubic foot of rock.	Authority.
		Pounds.	
Sand	2.65	165	Allen Hazen.
Gravel	2.66	165	A. E. Schulte.
Conglomerate	2.60	162	R. S. Weston.
Granite	2.70	168	E. C. Eckel.
Limestone	2.60	162	Do.
Trap	2.90	180	Do.
Slate	2.70	168	Tod's Tables.
Sandstone	2.40	150	E. C. Eckel.
Chagres River blue clay	2.62	163	Ancon Chemical Laboratory.
	2.57	160	Bureau of Soils, U. S. Department of Agriculture.
Sandy clay overlying blue clay from Chagres	2.71	169	Ancon Chemical Laboratory.
	2.63	164	Bureau of Soils, U. S. Department of Agriculture.
Blue sandy material from Gatun Island test pit, about 25 feet below surface.	2.72	170	Ancon Chemical Laboratory.
	2.70	168	Bureau of Soils, U. S. Department of Agriculture.
Red clay (residual) test pit near Gatun, spillway 4 feet deep.	2.67	166	Do.
Sandy soil on Gatun Island, 7 feet deep	2.65	165	Do.
Blue clay from Corozal (sedimentary)	2.70	168	Ancon Chemical Laboratory.
Yellow clay from Corozal (residuary)	2.69	168	Do.

The following report was made on several samples of soil from the Gatun dam location by the Bureau of Soils, U. S. Department of Agriculture, at the request of the chief engineer of the Isthmian Canal Commission.

REPORT ON PHYSICAL EXAMINATION OF FIVE SAMPLES OF SOIL FROM SITE OF THE GATUN DAM ON THE ROUTE OF THE ISTHMIAN CANAL.

(a) MECHANICAL ANALYSES.

The mechanical analyses are made by the method of the Bureau of Soils, as detailed in Bulletin No. 24 of that bureau.

The results are given in the following table:

TABLE 19.—*Mechanical analyses.*

Grade.	Diameter.	Conventional name.	Per cent.				
			Soil No. 1.	Soil No. 2.	Soil No. 3.	Soil No. 4.	Soil No. 6.
	mm.						
No. 1	2 -1	Fine gravel			3.8	2.5	0.5
No. 2	1 -0.5	Coarse sand	0.1	0.9	18.1	1.7	2.4
No. 3	0.5 - .25	Medium sand	.3	4.4	64.1	16.1	43.9
No. 4	.25 - .1	Fine sand	5.0	16.9	5.8	20.0	26.9
No. 5	.1 - .05	Very fine sand	10.5	14.7	4.9	38.7	18.3
No. 6	.05 - .005	Silt	63.5	40.9	4.9	21.2	7.5
No. 7	.005-0	Clay	20.8	22.1			
			100.2	99.9	100.4	100.5	99.5

The following descriptive note was inserted: Soil No. 1, blue clay from down the Chagres River; soil No. 2, red clay from one of the shallow test pits near the spillway, about 4 feet below the surface; soil No. 3, sandy soil overlying blue clay from down the Chagres; soil No. 4, soil on the island 6 or 8 feet from the surface; soil No. 6, blue sandy material from test pit on the island about 25 feet below the surface.

(b) and (c) POROSITY AND SPECIFIC GRAVITY.

The word "porosity" as applied to soils has two distinct meanings: (1) The percentage of pore space in the soil, and (2) the permeability of the soil to water (or air). The former meaning is used in this report. Permeability is referred to as such.

The porosity of a soil depends not alone on the size and shape of the soil grains, but on the packing and shaking to which the soil has been subjected and on the degree of flocculation possessed by the soil. It is therefore evident that the journey from Panama to Washington must have seriously affected the porosity of the samples under examination, and especially since the samples were moist, and had probably changed in moisture during the journey. It has been recently shown in this laboratory that the water content of a soil greatly influences its flocculation and hence its pore space.

The determinations of porosity given below can not therefore be considered at all reliable as indications of the conditions of the soil *in situ*. To be trustworthy, porosity determinations must be made in the field.

The permeability of soils can not be determined on a small sample, and only in a very rough way on a large one. It bears no simple relation to the porosity, since it depends not so much on the pore space as on the size of the individual spaces. A sandy soil is usually much more permeable than a loam or clay, though the latter may have higher porosities. The pores of the fine-grained soils are so small that fluids pass through them only very slowly. The porosity and specific gravity data are given in the following table. The apparent specific gravity of volume weight of the soil (column 2) is determined by weighing a known volume of the sample as received. The true specific gravity or specific gravity of the constituent minerals (column 3) is determined by the pyknometer method in the usual way. The water content (column 4) is determined by drying a sample at 110° C. From these data it is possible to calculate the percentage of the volume of the sample occupied by soil material and by water, respectively. The air space can then be found by difference. The total pore space or porosity (last column) is obtained by taking the sum of the air space and the space filled with water.

TABLE 20.—*Porosity and specific gravity.*

Sample.	Apparent specific gravity.	True specific gravity.	Per cent water (by weight).	Per cent of pore space by volume.		
				Air filled.	Water filled.	Total (porosity).
No. 1	1.42	2.573	46.48	4.25	66.15	70.40
No. 2	1.06	2.674	22.77	45.98	23.81	69.79
No. 3	1.60	2.639	13.17	54.10	13.12	67.22
No. 4	1.43	2.650	23.96	24.93	34.13	59.06
No. 6	1.80	2.701	19.74	11.19	35.45	46.64

For the purposes of this paper the following designation is given to various soil materials:

TABLE 21.

No.	Ordinary designation.	Size of soil grains.	
		Millimeters.	Inches.
1	Fine gravel	2 to 1	0.08 to 0.04
2	Coarse sand	1 to 0.5	.04 to .02
3	Medium sand	0.5 to .25	.02 to .01
4	Fine sand	.25 to .1	.01 to .004
5	Very fine sand	.1 to .05	.004 to .002
6	Silt	.05 to .005	.002 to .0002
7	Clay	.005 to 0	.0002 to 0

In his "Rocks, Rock-Weathering, and Soil," Professor Merrill classifies superficial and unconsolidated portions of the earth's crust as the "regolith," from the Greek words meaning a blanket of stone. Of this covering he makes the following subdivisions:

The Regolith	Sedentary	Residual: Residuary gravels, sands, clays, etc.
		Cumulose: Peat, muck, and swamp soils.
	Transported	Colluval: Talus and cliff débris.
		Alluvial: Modern alluvium, marsh and swamp, Champlain clays, etc.
		Æolian: Wind-blown débris, sand dunes, etc.
		Glacial: Morainal material, drumlins, eskers, etc.

Residual soils vary notably in their characteristics, depending upon the rock to which they owe their origin. In the limestone regolith the toughest clay lies next the rock, while in the sandstone region the soil below becomes less cohesive. The colors of the deposits, whether residual or transported, vary radically, but in such as are nearer the surface and recently exposed to those conditions, the colors are dull, some shade of brown or red, owing to higher oxidation and dehydration of the ferruginous matter set free by the decomposition of the iron-bearing silicates. From the color, therefore, it is often possible to judge from what portion of the regolith the material has come. If it has been exposed to oxidizing agencies, the depth of the sample will probably determine what those agencies were. Hence from the color one is able to judge of the presence or absence of oxidizing agencies.

It is not difficult to understand how surface wash, especially in times of flood due to heavy rainfall, can cause large quantities of débris to gather in the bottom of the rock valleys. The materials deposited by surface wash differ radically from stream-carried débris in bearing less evidence of the rounding action shown in stones carried along in running water. The water wear and sorting are at a minimum. When there is water enough to wear any material there is likely enough to wear coarse and fine together. The result is an accumulation of silt, clay, sand, and gravel commingled in every conceivable proportion. These gravels are mostly angular and are not appreciably waterworn. This deposit is not freely open to the flow of water, and if the rocks from which it has its source are soft and clay like, then the deposit is bound to take on a character similar to a soft concrete or to the "hard pan" of the glacial formation.

Of course, in the final analysis all rocks and deposits are transported, and at some time in their history their component parts have been brought from other localities. For the purposes of this paper, however, soils derived from the underlying rocks will be classed as "sedentary." The sedentary deposits clothe the hills and sides of the valleys, while to the bottom lands belong the transported deposits. These latter are the results of the eroding powers of the stream which, with the uplifting of the underlying strata, began the work of cutting down and carrying away. The burden of the stream was left along the length of the river bed, and the character of the deposit depended on the strength of the current.

The soils in the immediate vicinity of Gatun are simple in their primary classification, although rather complex in their make-up, especially in the transported material. The hills bordering the valleys are covered with a reddish-brown residual clay, the thickness of which varys up to a few feet or 20 feet and more. Its origin is the decomposition of the sedimentary rocks underlying it, and in the cuts made by the steam shovels appears the semblance of the stratification of the parent rock itself. This soil has the appearance and "stickiness" of clay, but has not its plasticity, nor has it the density and composition of the water-deposited clays. It is characteristic of this material that it dries readily and cracks near the surface. At the surface it is finely divided and plastic to a certain degree. As the underlying rock is approached it shows a tendency to cleavage and breaks up into roughly cubical fragments. For this reason the percolating waters, after passing through the cracks in the surface layer, easily find their way to the surface of the rock, along which they run with more or less freedom, dependent on the slope of the rock. Such material as this is more pervious than the sedimentary clay deposits, and, being less plastic, is not so good for use in making water-tight puddle and core walls as is the latter. Besides this, the hard cubical fragments near the rock surface do not readily lend themselves to uses of this kind; they have neither the water-tightness of the clays nor the weight and frictional resistancy of gravel and sand.

It seems evident that this part of the Isthmus was originally a sandstone region in which the Chagres has changed from a degrading to an aggrading stream. The valleys have been filled with clay, silt and gravel brought down by the streams and the "wash" from the surrounding hills. The result is an accumulation of fill in the valley several hundreds of feet deep, and composed of alternating beds of sand, clay, gravel, and silt. These beds are irregular and grade into one another both laterally and vertically. The fill is probably not the result of one period of aggradation, but the stream has several times changed from an aggrading to a degrading stream, but on the whole the aggradation has predominated.

The terms "clay" and "silt" indicate physical conditions rather than chemical or mineralogical composition, and they may, perhaps, be defined[a] as "indefinite admixtures consisting largely of more or less hydrated aluminous silicates and free silica, with lesser amounts of iron oxides, carbonates of lime, and various silicate minerals which in a more or less decomposed and fragmental condition had survived

[a] Merrill, "Rocks, Rock-Weathering and Soils," p. 117.

the destructive agencies to which they have been subjected. About the only characteristic feature is that of plasticity when wet, and this is dependent, apparently, upon texture and structure, i. e., upon the size and shape of the individual particles, and in some cases at least the presence of collodial matter."

ROCKS OF THE REGION.

Rocks may be grouped into three divisions: (1) sedimentary, (2) metamorphic, and (3) igneous.

Sedimentary rocks are formed of fragments worn from the older rocks by the action of rain, wind, frost, etc. Such materials, carried by the water, were deposited as beds of clay, sand, gravel, marl, etc. When first deposited, they were loose and unconsolidated, but later they became hardened and cemented together and formed solid rocks.

Concerning the sandstones, Merrill states that "many varieties are popularly recognised. Calcareous, ferruginous, silicious, or argillaceous (clay-like) sandstones are those in which the cementing materials are of a calcareous, ferruginous, silicious, or argillaceous nature."

Conglomerate or pudding-stone is merely a coarse sandstone; it differs from ordinary sandstone only as gravel differs from sand.

Breccia is a fragmental rock differing from conglomerate in that the individual particles are sharply angular instead of rounded. The term is made to include also certain volcanic rocks with a brecciated structure.

By this definition, the terms "sandstone" and "conglomerate" apparently mean the same thing, excepting that the particles in that rock known as sandstone are considerably finer than those in the rock known as conglomerate. This differentiation, however, is due to the coarseness of the particles forming the bulk of the rock, therefore one would not ordinarily class as a conglomerate a rock which was composed of fine sand, although it contained a few large pebbles. The ordinary idea of a conglomerate is a stone composed of large-sized gravel, smaller sand grains filling the interstices, and the whole mass bound together by some cementing material.

Metamorphic rocks are sedimentary rocks that have been subjected to heat and pressure.

Igneous rocks have come from the interior of the earth in a molten state, and have forced their way through other rocks or have overflowed as lava beds.

A succession of rocks possessing uniformity is called a "formation."

The slope of a bed is known as the "dip" and the direction in which the beds extend is called the "strike;" the dip and the strike are at right angles to each other.

The material of the earth's crust in the region of Gatun may be roughly classified as follows:

Rocks	Sedimentary	Conglomerate: Consolidated gravel.
		Sandstone: Consolidated sand.
	Metamorphic	Limestone.
	Igneous	Trap: Basalt (lava flow).
		Rhyolite (fragmentary tuff, volcanic ash).

The so-called "volcanic ash" is of igneous origin, and is a light-colored powdery deposit thought to have been blown into the air by

volcanoes, carried by the winds, and at length depositing in beds by settling through water. Interbedded with the sandstones, and frequently forming a considerable part of their thickness, are beds of exceedingly fine volcanic dust. This dust was blown out by volcanoes, and either fell into the lakes and settled to the bottom, or else, commingled by the violent rain storms that usually accompany volcanic eruptions, it was carried down into the valleys. In either case, between the periods of eruption the finely-divided materials, eroded by the river above, float down and settle in the lakes, causing the volcanic tuff, and the resulting rock shows the light and dark-colored banding of the materials together from such opposite sources. (Plate 83.)

The rhyolite strata may present entirely different appearances, due to the manner in which it was laid down. Molten rocks of this material were extruded by the volcano, and formed sheets before cooling which spread out extensively over the surface of the ground. In different form the lava which in the crater cooled enough to become hard and brittle, then, broken in pieces by the expansion of the steam, was blown into the air and the fragments distributed as volcanic dust. This, falling into the water, was sorted and laid down in beds similar to the water-borne sediments. The beds of this rhyolite tuff are much more numerous than is the compact massive rhyolite poured out from the volcanoes in molten condition. In many instances this rhyolite tuff is highly porous and permits the free percolation of water; in other instances it is firmly cemented and nearly impervious. Perhaps the method of its formation may throw light on its permeability. It might be expected, falling as dust on the surface of a lake and there caking and slowly sinking to the bottom, to have a cellular structure and offer opportunity to percolation. On the other hand, that portion of the dust that might be mingled by the rain into a sort of paste, running down into the valleys and there settling, would present a most impervious compound. Geologist Howe in his report (p. 114 of the Annual Report of the Isthmian Canal Commission for 1907) says: "The rocks are of sedimentary origin, and were deposited on the sea bottom at some distance from the shore in the form of sands and clays. Their subsequent hardening into rock is the result of simple cementation by calcareous solutions contained in the sea water and through pressure. Certain beds are harder than others, since the nature of their constituents favored more complete consolidation. The beds, however, are not to be regarded as *unconsolidated*.[a] They are all '*rock*,'[a] though in some instances soft enough to be loosened with a pick."

TRANSPORTING POWER OF WATER.

What a river can do as a transportation agent is obvious when it is realized that the weight of bodies which can be moved by a current of water varies as the sixth power of the velocity of the current, and the diameter of the bodies moved varies as the square of the velocity. If a pebble 1 inch in diameter and weighing 0.05 pound is rolled along when the velocity is 3½ feet per second, a velocity twice as great, or 7 feet per second, will transport a stone 4 inches in diameter and weighing 3¼ pounds. This power of transportation is especially noticeable when the velocity is decreased. If a 1-inch pebble is

[a] The italics are for the purposes of this report.

being carried along by the current of 3½ feet per second, and the velocity is suddenly decreased to one-half foot per second, the transporting power of the current then would be able to transport only fine sand and clay, and the coarse gravel and pebbles would be deposited in the stream bed. This physical law explains the occurrence of the gravel deposits in the upper reaches of the river, where there is a current too swift to deposit fine materials but gradually losing its load of coarser stones. It also shows the reason for the deposits of fine-divided clays and silts near the river mouths where the valley has broadened, the bed built up, and the current grown sluggish in its wanderings over the alluvium plane built up by the river itself. By a study of river deposits it is possible to trace the past history of the stream in the coarseness of the beds and banks.

TABLE 22.—*Transporting capacity of flowing water according to the calculations of Hopkins and experiments of Du Buat.—Quoted by Geikie's Textbook of Geology.*[a]

Inches per second.	Feet per minute.	Miles per hour.	Material moved.
3	15	0.17	Just move fine clay.
6	30	.34	Lift fine sand.
8	40	.45	Lift sand coarse as linseed.
12	60	.68	Sweep along fine gravel.
24	120	1.36	Roll along pebbles 1 inch in diameter.
36	180	2.05	Sweep along slippery angular stones the size of an egg.
48	240	2.72	Move large shingle.
60	300	3.41	Erode soft schist.
72	360	4.09	Erode stratified rocks.
120	600	6.84	Erode hard rocks.

[a] Quoted in Trautwine's Civil Engineers' Pocket Book, p. 577.

Merriman says that ordinary small loose earthy material will be transported by velocities of 2 to 3 feet per second.

Reasoning from the above, and realizing that as rivers approach their mouths their gradient becomes less and less steep, their width increasing and velocity decreasing, it would be expected that the deposits would be of finer and finer materials. Elsewhere it is shown that the velocity with which water percolates through soils varies as the square of the soil grain. From this it would appear that in the reaches of the river near to its mouth one would expect to find deposits impervious to the flow of water, while in the upper reaches the coarse gravels would give the freer flow.

CAPACITY OF ROCKS AND SOIL TO ABSORB WATER.

The amount of water that is permanently lost by descent to great depths is comparatively small. The amount that is held in the ground is not usually a considerable portion of the rainfall, and the amount of free water—that is, water available for use—is insignificant when measured by popular imagination. In certain localities, as Long Island, there are comparatively large supplies, but they are exceptional cases. Free water must be distinguished from absorbed water, since materials like clay hold great quantities of water, yet give up only very small amounts, and many rocks will absorb from 30 to 50 per cent of water, yet none is available to be drawn for use. The absorptive capacities of rocks and soils are usually expressed by

their porosities, although the ratio of absorption is sometimes used. Sandstone is the best water bearer of the solid rocks. Some of the fine-grained stones, however, are almost impervious. Conglomerates furnish some water, but, as a rule, their absorptive powers are much less than those of the sandstones. The capacity for absorption possessed by various materials is given below:

TABLE 23.

Material.	Porosity.	Evaporation, 24 hours.	Authority.
	Per cent.	*Per cent.*	
Silicious sand	25.0	88.0	Report on Water Supply, Vol. III. Final Report Geological Survey of New Jersey.
Gypseous soil	27.0	....	
Calcareous soil	29.0	75.9	
Barren clay	40.0	52.0	
Fertile clay	50.0	45.7	
Loamy clay	60.0	34.9	
Pure clay	70.0	....	C. C. Vermeule, Water Supply and Irrigation Paper No. 159, p. 16. U. S. Geological Survey.
Granite	.8	....	
Limestone	4.0	....	
Sandstone	20.0	....	
Sand	33.0	....	
Clay	40.0	....	
Granite	.16	....	Buckley-Wisconsin.
Limestone (marble)	4.85	....	
Sandstone	15.89	....	
Sandstone	10.22	....	Merrill.
Gypsum	7.18	....	
Quartzite	.8	....	
Quartzite	.21	....	Geikie.
Chalk	53.00	....	
Clay	53.00	....	
Clay	45.00	....	King.
Sand (uniform)	35.00	....	
Sand (mixture)	38.00	....	
Slate and shale	3.95	....	
Soils	55.00	....	U. S. Department of Agriculture.

In the third column in a few cases is given the percentage of water evaporated from different soils, which is seen to vary almost inversely as the capacity for absorption. If the resistance to evaporation is taken roughly to be a general measure of the resistance of the material to giving up water, this column also is a measure of the relative permeability of the several materials. Besides the character of the material, the amount of absorption depends to a great extent on the inclination of the porous beds, the amount being much greater in gently inclined beds than in those having steep dips.

Bedding planes are the surfaces separating beds of stratified rocks Where the character of the rock changes, these planes present more favorable conditions for the passage of water than other portions of the rocks, and especially is this true when two types of rock come together. Favorable conditions for the free passage of water through the rocks are the joints and fractures. With the exception of loose and incoherent masses like sand, gravel, and clay, all rocks, however they may be formed, are divided into blocks of greater or less size by systems of cracks known as joints. In the igneous rocks, all division planes are true joint planes and, varying in the way they intersect each other, they form more or less prismatic columns. In the sedimentary rocks the joints are ordinarily in only two planes, the third being the bedding plane.

Joints are very different in order of importance. Some, as the master joints, traverse many strata and remain constant for long dis-

tances and considerable depths, while each layer has its minor joints that are conformed to that layer. One set of joints, the strike joints, run more or less parallel with the strike of the beds, while a second set, the dip joints, follow the dip. The former are usually the larger and longer. Jointing is formed either by contraction due to the cooling of lava masses, or by stretching due to the folding and uplifting of all strata. It has been shown by experiments that a brittle substance, when twisted, cracks in two sets of fractures which intersect each other nearly at right angles, and in rock masses one of these fractures would usually follow the dip and the other the strike of the strata.

In any rock mass weathering is greatly augmented by lines of weakness such as joint and bedding planes. In homogeneous massive rocks the rate of disintegration is retarded by a lack of vulnerable points, and the resultant form is that of rounded bosses. Even when not sufficiently developed to be conspicuous such joints may exist as lines of weakness along which moisture and other agents of disintegration make their way, and the gradual rounding of the corners produces the oval bowlders. In nearly all such rocks exfoliation and decay take place in concentric layers like the coatings of an onion. Joints are the most common near the surface, and diminish in number and definiteness as depth increases.

That water is "lost" from the casing does not necessarily mean that there is an open saturated strata capable of absorbing all the water given it and flowing off like a river. In making the investigations for the North Dike of the Nashua Reservoir at Clinton, Prof. W. O. Crosby states (Water Supply and Irrigation Paper No. 145, p. 177) that "water was frequently lost at depths of 25 to 100 feet, although the head of water in the drill above the ground water must be little or nothing." This seems to prove quite conclusively that the water is absorbed by "thirsty" or exhausted strata, and does not rise in the saturated strata to overflow in the water table. The movement and storage of ground water may therefore be regarded as highly differential and complex in the basal and frontal portions of a delta, while relatively uniform and simple in the top sets and in the main body of the fore sets.

Mr. M. L. Fuller states[a] that joints are especially numerous in traps, conglomerates, sandstones, and shales. The sandstone beds are commonly jointed when exposed at the surface, but to what depth pronounced jointing descends is unknown, although the jamming of drills in wells may indicate that fissures extend to considerable depths in sandstone. Thus, in a well in Hartford, the drill, after having penetrated "blue stone," entered what seems to have been a conglomerate, soon after which it became jammed, presumably by encountering a joint plane. On its liberation, water began to flow. Again, at Hotel Rosswin, New Britain, a well penetrated 140 feet of sandstone, etc., without finding enough water to keep the drill wet, but at that depth the drill became jammed in what appeared to be a crack about 2 inches wide. As in the preceding well, an ingress of water followed the loosening of the drill. The apparent breadth of the crack may in reality be due rather to the presence of soft decom-

[a] Water Supply and Irrigation Paper No. 110, p. 103, U. S. Geological Survey.

posed rock along the joint plane than to an actual opening of the size indicated.

If the waters in the depths of the Chagres Valley were from a source other than the hills themselves, in dry seasons the streams and springs at the base of the hills would not dry up, but the joint planes mentioned above would serve as conductors for water, and a permanent flow would be established. This is not the case, as, at the beginning of the dry season, almost all of the small streams dry completely, although these beds are rock and not gravel as has been stated elsewhere.

The rôle that joint planes play when borings are made in rock is oftentimes very much underrated and sometimes ignored altogether. Oftentimes rocks that are practically impervious to the percolation of water are said to be freely water bearing, and when contradictory conditions are found in contiguous bore holes, it is remarked as a fact that this is past understanding. A little consideration, however, will bring out facts that will in a measure explain some of these phenomena. Figures 1 and 6, Plate 136, are presented as a diagrammatic sketch of conditions that have actually been encountered on this work. The sections are supposed to be normal to each other. This description is presented as a possible explanation of certain conditions that were exposed by borings made in the spillway at Gatun. Similar conditions were discovered in the case of the pollution of a driven well used for drinking purposes at Atlanta, Ga.

Figure 6 shows a pocket in the surface of the rock which retains some of the water that, having percolated through the soil layer to the coarse layer of disintegrated rock, is gradually making its way down along the sloping surface of the underlying rock. The numerous joint planes are shown in the figure by diagonal lines. In sandstone rocks these planes usually follow the direction of the dip and strike of the rock, and are generally normal to the bedding plane. A condition of this kind is shown in the photograph, Plate 85. Here the pocket and issuing stream are shown under the arrow, the joint planes are shown at "A" and "B," and the coarser material on the surface of the rock can also be seen.

It may at first be thought that the condition is theoretical, but that in practice very little water could be accounted for in this way. In the case shown in the photograph the gathering ground is quite limited, yet the flow has continued for several weeks in gradually diminishing volume. The quantity flowing was measured at least ten days after the steam shovel exposed the condition, and it was then running at the rate of 6 gallons per minute. The photograph was taken a week later than the measurement. The hole might be washed down to the rock, into which it might be chopped for a little distance when it crossed the joint plane p. v., Plate 136; the water used in driving the hole would disappear very rapidly instead of flushing up around the casing. It would be "lost," and the drill foreman would probably report in his daily record that he had chopped down through soft rock or gravel and had encountered a very porous stratum. This would be cased off with pipe and the drilling proceed, crossing another joint at "a" and "b" if they happened to connect with a reservoir, as is shown in the cut, water would run in the bore hole and it might then

be said that a water-bearing stratum had been encountered at "a." Casing would then be continued, but in order to stop the flow it would have to extend to "b;" then the record would state that a water-bearing stratum was encountered having a width the distance from "a" to "b." In case of well 2, water would be encountered at "c" and "d" and the water-bearing stratum said to be of this thickness. Thus appears the so-called remarkable condition of the same strata furnishing water to one hole and none to another, and at various depths. These joint planes are often plugged up by the material which the water carries along with it, and the joint plane "p. o." may be so closed at point "w" but open below "k;" in this case the water would be lost from the casing and a porous open stratum perhaps reported. These conditions would not be so misleading in a hard-rock stratum, for then the crossing of joints and seams would readily be noted, as is usually the case with experienced runners. But in a formation which is easily chopped through and which, while hard and impervious in places, is soft and friable when exposed, the conditions require careful interpretation.

In figure 6, Plate 136, if well No. 3 should cross the joint plane "p. o.," shown in figure 1, which cuts the strata in the same general direction approximately as this section (fig. 6), then the conditions of artesian flow would be established, the head and supply depending on the height and capacity of the reservoir over the surface of the rock at the side of the cut.

Referring these conditions to the Gatun spillway, it is found that the dip of the strata is in a northerly direction; that when the bottom of the excavation was 20 feet higher there was much more water than at present, although the rainy season had not then been fully under way; that the westerly side of the rock cut shows water the length of the cut, while the easterly side is comparatively dry. If the water encountered was coming from underground sources it would increase rather than decrease; it would also cease to flow from the side of the cut and be concentrated in the bottom. The west diversion gorge on the west and the old Chagres gorge on the south effectually cut off any supply above elevation 1. It therefore seems reasonable to presume that all water coming into the spillway from above elevation 1 must come from local sources, and the varying elevation of the ground water in neighboring holes seems to indicate this. At hole No. 1064, center line and axis, a stratum of sandy rock too soft to core was passed through at elevation −15. No water was found there, while at No. 1069, north, the artesian flow noted above was encountered. This flow was started June 8 and had exhausted June 13. This hole again began to throw water when pumping in the spillway pit was discontinued.

In a hole 300 feet north of the above water flowed for a time and stopped. If the flow was supplied from a water-bearing stratum of extent sufficient to reach from the neighboring hills or from some far-off upstream supply it could not be exhausted by any discharge so small as that of a 2½-inch bore hole; also it would be continually increasing its discharge if anything, due to the gradual washing out of the fine materials near the hole and thus enlarging the sphere of reception at the bottom of the casing.

ROCK FLOWS.

[From Water-Supply Paper U. S. Geol. Survey No. 145.]

In one of the regions in southeastern Michigan visited by the writer in 1904, there were several flowing-well areas in which waters partaking of the character of rock waters rose under artesian pressure from the fissured superficial portion of the rock just beneath the surface clays.

The locality visited is in southern Wayne and northern Monroe counties, and lies along the lower course of Huron River. The region is characteristically flat, the surface materials consisting in general of stiff, sometimes pebbly, clays, covering to a thickness of from 20 to 60 feet a slightly irregular rock surface mainly of limestone or sandstone.

A careful study of the wells showed that the water simply occupied the fissured upper portion of the rock and moved eastward entirely independently of the character of the rocks or their dip. Following the wells westward, it was found that the source of the water was in the drift hills resting on the rock a few miles to the westward, against which the clays, serving as an impervious cap to the rock, terminate at a level higher than that of the flowing wells.

The fissures in the rock appear to be largely of the nature of joint and similar cracks, and were probably opened under the influence of the weather when the rock was exposed at the surface before its burial by the drift. Solution crevices dissolved in the limestone by the percolating waters also form a part of the fissure system. In general, the crevices are most numerous near the surface, the water being commonly found within a few feet of the top. It is probable, however, that some of the fissures reach considerable depths and will yield water to deep wells. The water in its passage through the rock dissolves from it more or less mineral matter, so that when it issues once more from the wells it possesses the characteristics of a rock water.

Plate 168, figures 3, 4, 5, and 6, show condition of flow from joints in stratified rocks.

ARTESIAN CONDITIONS.

ARTESIAN WELLS.

The term "artesian" in connection with driven wells often is taken to mean wells from which a flow of water is obtained rising above the surface of the ground. The elevation of the ground surface, however, may be merely accidental when compared with the pressure in the water-bearing stratum. Of two wells piercing the same stratum, one may overflow and the other not, due to the relative elevation of the surface of the ground. It is better, therefore, to consider all wells in which the water rises above its stratum as artesian, and to designate them as "flowing" or "nonflowing."

Above the comparatively narrow gorges at Gatun are wide valleys filled with the alluvial deposit. If there were any considerable amount of water running through these narrow gorges, the flow would be so concentrated that a considerable velocity would be created, and the water would have forced its way into and through any stratum that it could possibly erode. Now, it appears that contiguous holes, having in the bottoms similar materials, in one case show the exist-

ence of artesian water, while the next hole is comparatively dry. One can be pumped out with buckets; the other shows a flow with pressure. This is a most evident indication of the nonexistence of any connected underground-stream flow. The indications are for water in the material under pressure, but with no flow, as might be the case if the water were furnished from joints and seams. The surface-water streams seem to flow in the dry season. No loose gravel beds appear under any of the smaller tributary streams, but the surface waters percolate through the disintegrated rock covering, and flow along between the solid rock and its decayed covering.

1. A well near the test pit on Gatun Island was carried down through a water-bearing layer, and was then capable of being drained of water with a hand bucket down to 100 feet below the surface of the ground. When the casing was pulled, the hole immediately filled with water to the level in the upper layer, and it was then impossible to drain it by the means previously adopted, yet the material obtained from the bottom of this hole by drive sample was exactly similar to that obtained in hole No. 1054, in which a very considerable artesian flow was encountered

SOME CONDITIONS AFFECTING SUBTERRANEAN WATERS.

[Bulletin of the U. S. Geological Survey. p. 19.]

From the paper by Prof. T. C. Chamberlin, entitled "The Requisite and Qualifying Conditions of Artesian Wells," the following notes have been taken.

The simplest condition of underground waters is shown in Plate 169, figure 3. The water enters the coarse stratum over the belt AA, and flows down the dip, being confined to the coarse stratum by impervious materials above and below. When it is tapped at B, it rises to a level approximately as high as AA. On the Coastal Plain there are probably several qualifying conditions of greater or less importance. The first is shown in Plate 169, figure 4. This represents a diminution in the coarseness of the materials down the slope, until finally the bed becomes so fine grained as to be impervious to water. Under this condition a well at C would afford water, but one at D would not. In case this finding of materials were in irregular beds or in local areas, the districts underlain by water would be restricted to the areas of coarse materials.

This relation is probable throughout the Coastal Plain, for the old shore of the deposits was near A and the fineness of materials increases offshore in most, if not all, of the formations. Beds which contain much water to the westward sometimes prove to be entirely fine grained and barren of water to the east and southeast.

A third condition, which is quite widespread from Fredericksburg southward, is shown in Plate 169, figure 6. This represents an overlap of fine materials across the catchment outcrop of the coarse beds, and this relation probably greatly diminishes the amount of water in the permeable bed.

Figure 4, Plate 170, is introduced to illustrate the reason why some of the beds to the westward which hold water have not yielded or possibly may not yield water to the eastward.

Figure 3, Plate 170, has a somewhat similar practical bearing, but beds which are widely overlapped by impermeable deposits in one

part of the region are often bared in other areas and receive ample water supply diagonally down the dip.

There are many local conditions that affect individual wells or small areas which should be illustrated here, for they are often referred to in the following pages. They are represented in the sections in figure 1, Plate 170.

Section 1, figure 1, Plate 170, represents a gravel bed merging into clay or fine sand in a circumscribed area. Wells at B and C, and probably at D, would find water-bearing gravels on the crystalline rock floor, whereas at A there would be clays all the way down and no water would be obtained. In some cases at A the gravels might continue, but with a clay matrix which excludes the water.

Section 2, figure 1, Plate 170, represents the occurrence of a gravel bed which is completely inclosed in clays, so that no water can accumulate in it, and a well at A, although finding favorable materials for water, would obtain none.

In figure 7, Plate 169, a condition is illustrated which is in a measure similar to that shown in section 1, figure 1, Plate 170. The water-bearing beds lie in channels, as it were, with intervening beds of nonwater-bearing materials. In this case wells at A and A would be successful, but those at B and B would not be.

In figure 9, Plate 169, a condition is shown which is frequently met with along the western border of the Coastal Plain in Maryland and northern Virginia. The water-bearing beds lie above sea level and are cut across by a depression, so that the water may escape in springs. Accordingly a well at B would usually find but little water, notwithstanding the fact that a well at A finds an abundant supply in the same beds.

CONDITIONS WHICH PRODUCE FLOWING WELLS.

[Annual Report of New Jersey State Geologist for the year 1895, p. 169 et seq.]

Besides these conditions given by Professor Chamberlin, there are others which depend upon a different hydro-dynamic principle. The water-bearing stratum may be of uniform character throughout, and may have a free outlet below for the water, and may, nevertheless, not produce flowing wells. This is owing to the fact that there is resistance of a pipe or conduit carrying water. It is well known to hydraulic engineers that such a pipe as the one, 48 inches in diameter, which supplies Newark with water from the Pequannock River, for instance, uses up a certain amount of head for every foot of its length in overcoming frictional resistance. Under ordinary conditions, for this particular pipe, this amounts to 2 feet for each 1,000 feet of length. Now, even when the pipe is discharging its normal amount of about 35,000,000 gallons into the Newark reservoirs, some 284 feet lower than the intake, if a vertical standpipe should be connected with it at a point 10,000 feet downstream from the intake, the water would rise in this standpipe to within 20 feet of the level of the intake. If the standpipe is 20,000 feet down the stream, the water will rise within 40 feet of the level of the intake, etc. A line connecting the levels of water in a series of such standpipes would be known as the hydraulic grade line of the pipe or conduit. A water-bearing stratum discharging freely at its lower end may have a similar hydraulic grade line. Thus, as shown in figure 1, Plate 168,

the pervious water-bearing stratum of sand or gravel, ABC, having an elevated outcrop at A and a free discharge at C, will have a hydraulic grade line ADC, and if a well tube be sunk at any point D into the previous stratum, the water will rise in the tube to this imaginary hydraulic grade line.

In the flat bottom of a valley (Fig. 5, Plate 169), and extending somewhat on the slopes, there is a local deposit of clay or alluvium rather pervious to water. This is underlaid by a pervious gravel, or it may be a seamy rock, like red shale. The rainfall collected in the upper portion of the valley passes down under the edges of this bed of clay, and then must find its outlet underground, beneath the clay, to a point lower down the valley. If wells be sunk through the overlying clay in such a case, at A, D, or C, the water will rise a few feet above the surface of the clay. It does not follow that the overlying bed must be absolutely impervious. Some water may be constantly forced up through it and seep into the natural drainage channels, but this requires a slight head, which is represented by the few feet to which the water will rise above the surface when an opening is made through the clay-bed. In such cases, especially if the well happens to be sunk into the rock, the fact that it flows to some height above the surface is often accepted as conclusive proof that it has a distant source, but our illustration gives the true explanation and shows that the gathering ground of the wells may be only a few hundred feet distant. Finally, it is conceivable that, in certain cases, wells may flow for a time from pressure exerted upon the water in the earth by compressed gases. A well put down at Sandy Hook struck gas at 150 feet deep, having a pressure estimated at 200 pounds per square inch which "shot the sand and water into the air to a height of 75 to 100 feet, but gradually fell off, and in three days exhausted itself, after throwing out several hundred yards of sand and dirt with water." (See Annual Report for 1896, p. 185.) Had such a well not penetrated the body of gas itself, but only a body of water against which the gas pressure was exerted in such a manner that the gas could not escape through the well, the result would have been a flowing well of more or less permanence.

FLOW OF WATER THROUGH SAND AND GRAVEL.

UNDERFLOW CONDITIONS.

All of the water that flows, either on the surface or underground, has its primary source in the water that comes from the clouds. The rainfall, when it reaches the earth, is disposed of in three general ways: (*a*) That which flows off over the surface and finds its way more or less quickly to the surface streams; (*b*) that which is evaporated and thus returns to the clouds, and (*c*) that which sinks into the ground and is used by plant life, or held more or less securely in the underground reservoirs. In connection with this last amount, there is a great deal of popular fiction regarding the immensity of the underground storage and the huge and inexhaustible rivers that are rushing seaward, carrying quantities of water beside which the surface streams are insignificant. If one considers that the underground water is from the same source as that flowing in the streams and that usually the same catchment area gives the supply to both, the fallacy of the unlimited underground supply is more easily perceived.

The ordinary porosity of sands and gravels may be taken as from 30 to 36 per cent of the material. This means that, even if there were no friction to retard water in flowing through such beds, there would only pass underground about one-third of the amount that flows in surface channels of the same area. But, as is shown on page 159 and following, there is great obstruction to underground flow, even in the coarsest gravels.

The underground water of the Chagres Valley at Gatun is either from an underground stream making its way seaward through a porous medium, or else it is water falling as rain in the neighboring hill slopes and slowly finding its way down hill to the lowest portions of the valley. There, held down and backed up by the heavy blanket of impervious clay, it exists under pressure in the interstices of the sand and gravel pockets. These are of greater or less extent as unequally deposited by the meandering river and by the varying velocity of the water—now swift and capable of moving gravel in times of flood; now slow and depositing the finest sand and clay.

In the upper reaches above Gamboa, and to a less degree above Bohio, the bed of the river is rising and the current is always comparatively swift. Here one would expect, as is the case, to find the entire bed covered with gravel and sand. As the slope of the bed becomes more and more flat, the velocity of the current becomes less and less, the carrying power decreases, and the deposits are composed of finer and finer particles. From Bohio to Gatun, a distance of 8½ miles, the bed of the stream has a slope of less than 1.5 feet per mile. In ordinary seasons the current is sluggish and a great silt carrier. In seasons of floods the river becomes suddenly a raging torrent, capable of moving heavy materials of considerable size. But these periods are flashy; the flood comes and goes in a few days. Even the big flood of 1906 lasted only four days. During these flood periods the river moves along gravel and sand, and, as the velocity decreases, this is deposited. Now succeeds a period of slower velocity. The rain has ceased and the river is falling. Its load of sand and gravel has been deposited, but the finely divided silt and clay is still borne along from the headwaters, and the load of this matter rapidly increases from all along the stream. When this burden comes into the sluggish waters in the lower reaches it begins to deposit, and quickly covers gravel and sand deposits previously laid down by the river in its swifter period. Thus are formed the lenticular pockets of sand and gravel embedded in the clay deposits of the river. Laid down in this manner, it would not be expected that there would be continuous sand and gravel layers in the lower and flatter portions of the river. This inference is borne out by the borings in the vicinity of Gatun. There are no crystalline rocks near Gatun; therefore there are no beds of sand and gravel formed from local erosion. The sedimentary rocks are comparatively soft, and the continued rubbing and wearing of the water reduces them to clay and not to the rounded particles that make up the enduring sands and gravels. The slope of the river is too flat to bring down the coarse gravels and sands that make up the continuous deposits above Bohio. The surface streams in the vicinity of Gatun flow over beds of soft sand rock in their higher portions, and in the valleys they have cut their channels in the alluvium of the river bottoms. Formed as above, gravel and sand beds

of limited extent only are found in the clay deposits. Some of these are water bearing, and some others a short distance away have no water. Bore holes in the immediate vicinity of each other show entirely different formations regarding the occurrence of the gravel and sand layers and the characteristics of the materials themselves.

Wells and bore holes sunk a few feet to rock discover a considerable pressure at times, although no water is apparent on the surface. The weathering of the surface of the underlying rocks presents much the more porous medium directly on top of the hard rocks themselves, and the covering becomes more and more impervious on approaching the surface. This clay-like covering also becomes thicker as it approaches the level floor of the valley, due to the accretion of material washed down from above by surface flow. We have now the condition of water falling on the hillsides and percolating through the surface layer until it reaches the rock. Along this sloping surface it flows in gradually increasing volume until it reaches the rock in the valley floor. But here, pent in by the ever-increasing thickness of the impervious clay covering, it is unable to force its way in any considerable stream to the surface and remains stationary, but under the pressure due to its origin or to the weakness of the overlying strata. When the water of the hills has filled this basin below (and it may be likened to a space that might be found between two dishes which could be filled with water to their brims), then this basin must overflow in springs even as the water between the dishes would run over the edge if too much were poured in. Tap a hole in the bottom of the upper dish and you have all the phenomena of the artesian flow in the valley of the river. Besides the pervious medium immediately above the rocks, some of the rocks themselves are very porous. Now, this water under pressure is looking for a way to escape, and as it slowly travels along it comes to these lenticular deposits of gravel and sand. These it immediately fills with water under the pressure due to the hills, if the layer of surrounding clay is not too thick to be penetrated. During the long ages water has penetrated the clay coverings to some extent.

If, now, a bore hole is sunk into one of these pockets, water under its original pressure immediately runs in the pipe. If the top of the pipe is below the elevation of the water rim in the hills, then an artesian flow is established. If the bore hole has penetrated the pervious layer on top of the rock, if the rock itself is very porous, or if the gravel deposit was laid down originally in the pervious layer on the rock, then a continuous flow is established, its permanency depending only on the size of the tributary basin, i. e., if the dishes were extremely large and the pipe extremely small, it might flow forever, depending only on the supply from the rainfall to keep the space between the dishes filled to the brim. This case seems to exist in well 1054, for example. Again, the bore hole may penetrate a sandy or gravelly layer and at first no flow appear, but later water may come to the surface, although the hole was not lowered. This condition was found in bore hole No. 1079, and may have been due to an impervious clay layer between the sand pocket and the high-pressure water on top of the rock, which was thick enough to prevent water penetrating the sand layer under ordinary conditions, but too thin to stand the pressure when the superimposed weight of the gravel above was

removed. Still, again, pockets of water have been found which flowed for a time under head and then the flow gradually diminished and at length ceased. This might be due either to pockets of natural gas, the product of decaying vegetation, or else from water in the gravel pockets under pressure from the hills, but the supply maintained by slow percolation through the clay envelope. When this was first opened, the pressure caused the water to rise, but as the supply was limited the discharge soon ceased.

There seems to be no indication of a continuous underground current in the valley of the Chagres parallel with the surface flow. This condition would require continuous gravel deposits which are not shown by the borings. There should be shown a well-defined hydraulic gradient. This does not appear. Along lines approximately at right angles to the axis of the dam in a distance of about 300 feet, special pains were taken to discover such a condition, and, while in some of the holes considerable water under pressure was found, careful investigation has failed to establish any continuous underlying water-bearing stratum. In holes 200 feet apart, some have flow and others do not. On account of the above, it appears: (1) that pervious materials are not continuous, but are ancient sand and gravel bars buried and surrounded by an impervious envelope of clay; (2) that the water discovered by the bore holes derives its pressure and source from the hills surrounding the valley; (3) that the layer most to be feared for its water-bearing capacity is a stratum of sandy clay comparatively near to the surface. This layer is supplied by surface water only, and, not having been consolidated by the weight of the superimposed materials, is more or less capable of interstitial flow. In its present state water is not able to readily flow through this material, as is shown by the experiments. Probably the immense weight of the proposed dam would still further tend to consolidate it. Nevertheless there is a layer of drained soil on top of this layer which might act as a bridge and prevent the full weight of the embankment being felt. If a row of sheet-piling were to be driven entirely through the sand and gravel layer into the stiff clay beneath, it would effectually stop any movement of water through this layer, either from the hills or lake. Any porous strata in the spillway can be cut off by a curtain wall reaching into impervious rock, and such would be the case in the locks. After the dam is completed, its own slope and proper precautions at the extreme ends will effectually dispose of the water that is now finding its way to the lower levels.

On account of the gathering area and the impermeability of the intervening clay beds, the amount of water seeking underground passage through the older beds is very much less than in the deposits above this layer, and whatever scouring power water may have to clear gravel beds of their fine interstitial materials is much more effectively exerted in the upper than in the lower beds. Although water pent up in this layer gushes out at times from wells, it must be borne in mind that its actual power for scour at the bottom of the gorge is no greater than the head causing the free discharge at the surface. When an artesian flow is seen breaking from a pipe and playing 10 or 15 feet into the air, its power then is impressive, and the power exerted by it 200 feet below the surface can only be imagined. This power of water, however, can only be exerted when there is a

free outlet, and if the materials surrounding a porous bed are sufficiently impervious, or if the bed itself is of sufficient extent there can be very little motion or velocity even with the greatest head. Again, the ultimate destination of all water is the ocean, and although the pressure at the bottom of the hole may be sufficient to raise gravel of large size through the free outlet afforded by a pipe the actual power of this water to wash out fine materials is governed by the height it will rise above the level of the water in the sea, and the distance its outlet from under its impervious clay blanket may be from the point where its head was measured.

The earth's crust may be divided into three zones according to the conditions of underground water circulation:

1. The unsaturated zone extending from the surface of the ground down to the upper surface of the ground-water body, or the "water table."
2. The zone of shallow, or "surface waters," extending from the water table down to the first impervious stratum of considerable extent.
3. The zone of deep-seated waters, lying below the first impervious stratum.

The unsaturated zone may contain a considerable amount of water, not stationary, but in transit to the zone of shallow waters. The zone of shallow waters is usually a unit and continuous over a considerable area. The zone of deep-seated waters is not a unit, as there are in most cases several subdivisions, depending on the permanence of the impervious strata in the zone. The water table shows a general agreement with the slope of the surface. The undulations of the water table are less marked, however, than those of the land surface, the water standing considerably below the top of the ground on the summits of hills and practically at stream level in the valleys. In humid countries the ground-water surface is very near the surface of the ground, due to the frequent replenishment of the zone of saturation.

The amount of water stored underground represents the slow accumulation through long periods. Some accession is received from the surface and subsurface flows; some is received through absorption from flood waters, but the main portion is received along the inner edge of the valley at the base of the hills and under the clay subsoil. The water beneath such a sloping impervious clay bed finds its exit along the lower edge of the bed, but, checked by the increasing imperviousness of the strata through which it is passing, or by a fold in the strata, or by an earlier ridge (see rock conditions south of dam) against which they abut, it accumulates head and flows to the surface of the ground when the overlying confining mass is pierced by a drill.

This is the general explanation of the artesian conditions which prevail here. From the valley up the hills the water table rises, giving the conditions for artesian pressure in the valley. As has been stated, all waters are journeying seaward with greater or less speed, and the finer and more compact the material the slower will be the rate of motion but the higher the static head may be. The most finely divided and impervious materials are those which the current of a river carries the farthest, and the beds are graded from coarse to fine down the valley, the finest nearest the sea.

Mr. Ernest Howe, the geologist, who examined and reported on Isthmian geology, made a detailed statement [a] regarding the filling

[a] Annual Report, Isthmian Canal Commission, 1907, p. 127.

in the valley of the Chagres, and to facilitate reference his conclusion is here reproduced:

One should expect to find at the bottom of such a gorge as the Chagres at Gatun a comparatively thin deposit of coarse gravel, sand, and a few bowlders, while the greater part of the alluvium should be of the finest clay and silt with a certain amount of fine gravel and sand mixed with it. Such, in fact, is the character of the alluvium filling the gorge of the Chagres, as shown by numerous borings made at Gatun. The boring records indicate considerable sand and gravel at points comparatively near the present surface; it is unlikely, however, that any sand or gravel, unmixed with clay, occurs in the deposits except at or very near the bottom. The reason for the boring records specifying "sand and gravel" as they do is that, when samples are taken from time to time during the process of sinking the hole, only the coarsest material is collected, the finer clay being held in suspension and carried off with the water flowing from the hole. In certain of the holes temporary flows of water were encountered, but after a few hours the flow invariably ceased. Such flows are believed to occur when, in the course of making a boring, the casing is introduced into a lenticular deposit of sand or water-bearing gravel under pressure from the overlying beds. The sands, being surrounded by much less pervious material, are in the nature of reservoirs in which water is stored under pressure, and when this pressure is released at the point where the casing enters the sands, water may rise to the surface if under sufficient pressure, and flow from the top of the casing until the pressures are readjusted. Far from indicating porous materials underlying the site for the dam, the occurrence of such flows only proves the extremely impervious character of the materials lying between the surface and the water-bearing beds.

Beds of porous material up the river become saturated with water, which slowly and more slowly permeates the less porous beds down stream until they are thoroughly saturated, but have very little movement. This water is under great pressure, and when the drill hole comes near the stratum the water will break through with a rush. As the flow continues it increases, due to the ever cleaning and enlarging of a sphere at the entrance of the well pipe. Earthy and clayey matter which formerly made the layer impervious is now washed out, and the samples show a coarse gravel of a very porous character which entirely falsifies the material, that drive samples of the material in place taken before the flow commenced would have shown to be almost impermeable to the flow of water.

THE FLOW OF WATER THROUGH SANDS AND GRAVELS.

The phenomena of the flow of water through sands and gravels has been most thoroughly studied by Mr. Allan Hazen and by Professor Schlicter. The results of the determinations by the former appear in the report of the Massachusetts state board of health, 1892, while those of the latter are found in the Nineteenth Annual Report of the United States Geological Survey, Part II, and in Water Supply and Irrigation Papers Nos. 67 and 140 of the same department. Professor King also has articles on this subject in the Nineteenth Annual Report of the Geological Survey. The formulæ which are most used for such determinations are those of Hazen and Schlicter:

Hazen's formula.

$$v=\frac{cd^2h}{l}\times\frac{t(\text{Fah})-10^\circ}{60^\circ}$$

Where v=velocity in meters daily of a solid column of the same cross section as that of the sand.

d=the effective size of the sand grains in millimeters.

c=a constant varying from 450 to 1,000 according to the cleanness of the sand.

h=the head of water causing motion.

l=the thickness of the sand layer; ($\frac{h}{l}$=slope of ground-water surface).

t=temperature in degrees Fahrenheit.

Schlicter's formula.

$$Q=\frac{chd^2a}{luk}$$

Where Q=quantity of water transmitted by the column of sand in one minute.
h=difference in pressure at the ends of the columns, or the head under which the flow takes place, measured in feet of water.
a=the area of the cross section of the sand column measured in square feet. (It is to be borne in mind that "a" is the total area of the section including sand and voids, and to get "v' from the formula $Q=AV$, "a," must be multiplied by the percentage of porosity.)
l=length of column in feet.
d=the mean diameter of the soil grains in millimeters, or the so-called "effective size."
u=the number which takes account of the friction between the particles of water, and is the coefficient of viscosity; its value decreases rapidly with increase in temperature.
c=constant, given as 0.2012.
v=velocity in feet per minute through the sand grains.

The relative flow of water of various temperatures through a soil 60° F. being taken as the standard of temperature, is shown in Table No. 24.

TABLE 24.

Temperature.	Relative flow.	Temperature.	Relative flow.
° F.		° F.	
32	0.64	70	1.15
35	0.67	75	1.23
40	0.73	80	1.30
45	0.80	85	1.39
50	0.86	90	1.47
55	0.93	95	1.55
60	1.00	100	1.64
65	1.08		

The relative flow of water through sands of the same effective size, but packed so as to possess different porosities, is shown in Table No. 25.

TABLE 25.

Porosity or percentage of voids.	Relative flow.	Porosity or percentage of voids.	Relative flow.
26	0.50	40	2.09
30	0.81	42	2.46
32	1.00	44	2.88
34	1.22	46	3.33
36	1.47	47	3.57
38	1.76		

Regarding the flow of water, Professor Schlicter says:

It is seen from the above formula that the quantity of water transmitted by a column of sand depends not only on the length of the column and the head of water as expressed by Darcy's law, but varies in a most remarkable way with the size of the soil grains, with the temperature of the water, and with the porosity. Since the flow varies as the square of the size of the soil grains, this element in the formula has a most important effect, as doubling the size of the soil grain will quadruple the flow of water. Thus the flow through a soil whose effective size of grain is 1 mm. is ten thousand times the flow through a soil whose effective size of grain is 0.01 mm. The variation of flow with temperature is also important, as the flow at 70° F. is about double that at 32° F. The variation in porosity is quite as important as the variation in temperature. If two samples of the same sand are packed so that the porosity of one sample is 26 per

cent and the other 47 per cent, the flow through the latter will be more than seven times the flow through the former sample. If the two samples of the same sand are packed so that their porosities are 30 and 40 per cent the flow through the latter sample will be two and six-tenths times the flow through the former sample.

TRANSMISSION CONSTANT.

The resistance offered by sand or gravel to the flow of water which is percolating through it is very great. The water is obliged to pass through very small pores, usually capillary in character; indeed they are much smaller in cross section than the soil particles through which they pass. If the particles of sand or gravel which make up the water-bearing medium are well rounded in form, the pores are somewhat triangular in cross section, and the diameter of the individual pores is only one-fourth to one-seventh the diameter of the soil particles themselves. Thus, if the individual grains of sand average 1 mm. (one twenty-fifth inch and classed as fine gravel) in diameter, the pores through which the water must pass average only one-fourth to one-seventh (one one-hundredth to one one hundred and seventy-fifth inch) mm. in diameter.

If in Schlicter's formula (2) we express by a single character that part of the expression dependent only on the character of the soil and represent this by k, and use "i" for $\frac{h}{1}$:

$$k=\frac{cd_2}{upk} \tag{3}$$

and the formula for flow becomes

$$q=kia \tag{4}$$
$$v=ki \tag{5}$$

The constant "k" is the quantity of water that is transmitted in unit time through a cylinder of the soil of unit length and unit cross section under unit difference of head at the ends. This constant "k" is called by Schlicter the "transmission constant" of that soil. If the "transmission constant" of a soil is determined for a given temperature and porosity, by simple arithmetical computation based on the relative flow shown in Tables 24 and 25, and the relative pressure gradient, the flow under any other conditions is determinable.

The most convenient method of determining flow in soils is by means of the diagram published by Professor Schlicter[a] and reproduced as Plate 171.

The diagram is based on a temperature of 60° F., and is used as follows: Suppose that the amount of water transmitted by a sand per square foot of cross section is desired, if the effective size of the soil grain is 0.55 millimeter, the hydraulic gradient 2 feet in 100 feet, and the porosity is 36 per cent. Apply a rule or straightedge to the diagram, passing through the mark 0.55 on scale "d" (scale of diameters) and the mark 0.02 on scale "s" (scale of slope given in percentage). The edge of the ruler will locate a point 41 on "u" (an auxiliary scale for transfer purposes). Put the point of a pencil on 41 in "u," and move the ruler so that its edge will pass through 41 on "u" and through 36 on "m" (scale of porosity and appearing as a percentage). The plane where the edge of the ruler crosses line "q" (scale of discharge) 0.0036 gives the discharge in cubic feet per minute per square foot. This discharge multiplied by the area exposed will give the total quantity. The quantity flowing is based on the fundamental formula:

$$Q=\text{velocity} \times \text{area of cross section} \times \text{porosity}.$$

[a] Opposite p. 14, Water Supply and Irrigation Paper No. 140, U. S. Geological Survey.

Therefore, as the diagram gives the quantity per unit area, the velocity among the soil grains may be determined by the formula:

$$V=\frac{\text{Discharge per unit area}}{\text{Porosity of the material}},$$

and in the case above given the velocity among the sand grains would be at the rate of 0.001 foot per minute.

Other experimenters have given different methods of expressing the flow of water through sands and gravels, and some of these determinations are shown below in tabular form.

TABLE 26.—*Table for velocity of flow through permeable soils.*

[Values of k in formula $v=ki$; v=velocity in feet; i=inclination or fall in feet per foot.]

[Table taken from Bulletin No. 33, Agricultural Experiment Station, Colorado State Agricultural College.]

Kind of material.	Size of grains.	Proportion of voids.	Velocity.			
			Per second.	Per hour.	Per day.	Per year.
	Inches.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
Minute gravel	0.08	0.41	0.024	86.47	2,075	757,520
Coarse sand		.38	.0026	9.33	224	81,730
Fine sand	.008	.35	.00047	1.69	40.5	14,777
Sandy soil		.30	.00032	.79	18.9	6,897
Sandy clay		.25	.00012	.42	10.2	3,725
Clay		.20	.00003	.12	2.8	1,035
			.00008	.295	7.1	2,587

To use this table in practice it is only necessary to multiply the above figures for velocity by the slope of the surface of the groundwater in the soil, since for such soils the velocity varies directly as the slope. The table gives the velocity for a slope of 1 to 1, or 45 degrees.

The experiments of Darcy, as developed by Dupuit, establish the fact that the flow of water through sands is similar to the phenomena observed by Poiseulle in his experiments of the flow through capillary tubes.

Example.—What distance will water pass through coarse sand in a year, inclination being about 1 in 100?

Here $i=\frac{1}{100}$. If the sand averages $\frac{1}{12}$ inch diameter, without finer particles, it would approach what is here designated as minute gravel. In one year the distance would be the number 757,520 multiplied by the inclination, $\frac{1}{100}$, giving a distance of 7,575 feet, or about 1½ miles. If in coarse sand, as here termed, a distance of about 800 feet.

The following table, taken from Professor Schlicter's paper, gives the velocity of ground waters in materials of different grades, pressure gradient 10 feet per mile:

TABLE 27.

Material.	Diameter.	Velocity.		
		Per year.	Per year.	Per minute.
	mm.	*Miles.*	*Feet.*	*Feet.*
Fine sand	0.2	0.010	52.8	0.00015
Medium sand	.4	.041	216.0	.00041
Coarse sand	.8	.16	845.0	.00161
Fine gravel	2.0	1.02	5,380.0	.01025

If these velocities are referred to the Gatun dam, the following results:

TABLE 28.

Material.	Diameter.	Velocity per minute.	Material.	Diameter.	Velocity per minute.
	mm.	*Feet.*		*mm.*	*Feet.*
Fine sand	0.2	0.009	Coarse sand	0.8	0.105
Medium sand	.4	.027	Fine gravel	2.0	.666

The conditions of Table No. 28 are porosity of 32 per cent, temperature of 85° F., and a hydraulic gradient of 85 : 1,100 :: 1 : 13. Table No. 27 is based on a temperature of 50° F. and a hydraulic gradient of 10 : 5,280 :: 1 : 528.

The relative flow due to increased temperature is 1.62, and that due to increased hydraulic gradient, 40. Therefore, multiplying the quantity in the last column of Table No. 27 by 1.62×40 gives the result in Table No. 28. The conditions of this calculation suppose a column of the material noted in the table to have a length of 1,100 feet and to be exposed at one end to a pressure of 85 feet of water and a free discharge at the other end of the column. One thousand one hundred feet is about the length of the hydraulic-filled portion of the dam section at grade 0. The conditions imposed, therefore, assume that the material in the foundation is thoroughly clean and of a size as given in the table, also that the thick superimposed impervious clay layers do not extend beyond the limits of the dam. Plate 172 shows the discharge and velocity in permeable materials as referred to the Gatun dam. Plates 100 and 173 show conditions in alluvial valleys and the measured velocity of flow through the underground materials.

TABLE 29.—*Table showing rate at which water will pass through different sands, with various heads, at a temperature of 50° F, expressed in feet per day.*

Head.	Effective size of sand 10 per cent of grains finer than—						
	Mm. 0.1 Ins. .004	0.2 .008	0.3 .012	0.4 .016	0.5 .020	1.0 .039	3.0 .118
0.001	0.03	0.13	0.29	0.52	0.82	3.28	29.5
.005	.16	.66	1.47	2.62	4.10	16.40	147.0
.010	.33	1.31	2.95	5.24	8.20	32.80	295.0
.050	1.64	6.56	14.70	26.20	41.00	164.00	....
.100	3.28	13.12	29.50	52.40	82.00	328.00	....
.500	16.40	65.60	147.00	262.00	410.00	....	....
1.000	32.80	131.00	295.00	524.00	....	....	....
2.000	65.60	262.00	590.00	1,048.00	....	....	....

Head.	Effective size of gravel 10 per cent of grains finer than—									
	Mm. 3 Ins. .118	5 .197	8 .315	10 .394	15 .590	20 .787	25 .984	30 1.18	35 1.38	40 1.57
0.0005	12	33	66	98	164	262	361	492	656	820
.001	23	69	134	190	328	485	672	903	1,260	1,475
.002	46	131	256	361	624	903	1,210	1,570	1,930	2,330
.006	134	367	680	900	1,470	2,030	2,550	3,050	3,570	4,070
.010	220	570	980	1,260	2,000	2,730	3,360	4,000	4,630	....
.050	920	1,830	2,900	3,470	4,900	....	....	....	....	....
.100	1,620	3,050	4,300	5,100	....	....	....	....	....	....

This table is made up from the results of a number of experiments made in connection with the study of filter sands by Mr. Allen Hazen. The figures given are feet and inches instead of meters and millimeters as in the original, which was published in the report of the Massachusetts State board of health for 1892, page 554.

The above figures show the velocity of the water passing through 1 square foot of sand with the given slope, not the actual rate of travel of a particle of water through the sand, which will be faster in the ratio of the total volume of the sand to the volume of the voids occupied by the water, or about two and one-half times the velocity shown in the table, if the porosity is 40 per cent of the mass.

In order to show the improbability of any water flowing beneath the alluvial deposits in the Chagres gorges that may affect the stability of the dam, the following statements are given as the results of the investigations of the best-known experts along these lines: Professor Schlicter states[a] that "the highest velocity ever determined for ground water is about 100 feet in twenty-four hours." Assuming a porosity of 33 per cent, the actual velocity among the sand grains would be at the rate of 300 feet in twenty-four hours, or 0.21 foot or about 2½ inches per minute. Referring to Table 22, it is seen that a velocity of 15 feet per minute is necessary to move clay. Darton[b] states that the rate of flow in the sands of the Dakota formation, from which the remarkable artesian wells of South Dakota draw their supply, does not exceed a mile or two per year. Rogers[c] reported to the Denver Society of Civil Engineers that American estimates agree with the careful and exhaustive studies of the French engineers, which show the average velocity in sands to be about a mile a year, or about one-eighth of an inch a minute. Professor Forchheimer[d] states,[e] "In nature clean sands or gravels are rare, and the permeability of the alluvial deposits is therefore mostly a slight one." Public water supplies are generally taken from the most permeable strata that can be gotten at. The investigations made for waterworks are therefore of special interest. Table No. 30 gives the velocities (taken for the entire cross section of the soil) which ground water of about 10° C. or 50° F. acquire at a gradient of h: 1 : : 90 : 2,500 = 0.036 in some of the underground drifts studied for public supply.

TABLE 30.

	Lyon.	Strasburg.	Bergisch-Gladbach.	Augsburg.	Vienna.	Bucharest.
Speed in millimeters per second	0.068	0.179	0.099	0.148	0.034	0.051
Speed in feet per second	0.000224	0.000588	0.000292	0.000485	0.000112	0.000166

The seepage and inflows as observed in a number of instances are given in Tables 31 and 32.

[a] Water Supply and Irrigation Paper No. 141, p. 9.
[b] Eighteenth Annual Report U. S. Geological Survey, Part IV, p. 609.
[c] Engineering Record, Vol. XXV, p. 435.
[d] Professor of hydraulics at the A. D. K. K. Tecnischen, Gratz, Austria.
[e] Trans. Am. Soc. C. E., Vol. XLVIII, p. 303.

TABLE 31.—*Seepage from some canals.*

[Cubic feet of water per square foot.]

Canals.	Seepage per day.	Remarks.
	Feet.	
Fort Morgan, Colo	0.98	Sandy soil.
Do	5.00	New canal (1 equals about 0.01).
Hoover ditch, Colorado	1.2	Sandy soil.
Kings River and Fresno	1.5	Do.
Do	1.7	Do.
Fresno	0.4-2.8	Different sections.
Fresno laterals	1.2-6.4	
Naviglio Grande, Italy	.9	Italian canals 100 years old in very pervious soil.
Muzza, Italy	1.7	
Canale Martesana, Italy	1.5	
Languedoc, France	.23	Carefully constructed.
Chesapeake	.42	American canals in rather impervious soils.
Chenango	.42	
Erie	.42	
Morris	.71	
Delaware and Raritan	.71	

The ordinary rate shown above is from 0.4 to 1.5 feet for ordinary to rather pervious soils, ranging upward to 5 or 6 feet in extremely pervious soils. These figures (0.4 to 1.5) correspond approximately with Hazen's for inclination 0.01 and materials classed as 10 per cent finer than 0.004 to 0.008 inch, and it seems probable that such would be the average condition under which seepage occurs.

TABLE 32.—*Other rates of inflow.*

	Gallons per day per square foot.	Feet per day.
Infiltration galleries at Lowell, Mass., test showed that the inflow through sand and gravel was	150	20
Infiltration gallery at Brookline, Mass., material clean, coarse sand and gravel	245	33
Toronto Basin	52	7
Gallery at Perth, Scotland	182	24
Gallery at Angers, France	187	25
Gallery at Angers, France (new)	300	40
Gallery at Lyon, France	147	20
Gallery at Toulouse, France	228	30
Open well at Long Island City (W. J. Matheson & Co.) in fine micaceous sand mixed with gravel (1 equals 0.6)[a]	360	48

[a] Inflow to this well varied directly as the head.

These tables, Nos. 30 to 32, inclusive, were taken from the report of the state geologist of New Jersey for the year 1898. Commenting on Table No. 31, he says that "the figures given would seem to indicate that ordinary sands mixed with gravel, as they occur under natural conditions, offer as much resistance to flow as Mr. Hazen's sands 10 per cent finer than 0.012 inch."

Respectfully submitted.

C. M. SAVILLE,
Assistant Engineer.

Lieut. Col. GEO. W. GOETHALS, U. S. Army,
Chairman and Chief Engineer, Isthmian Canal Commission.

(Through Maj. Wm. L. Sibert, U. S. Army, commissioner and division engineer, Atlantic division, Isthmian Canal Commission.)

APPARATUS USED IN TESTING PERMEABILITY OF ROCK IN VICINITY OF GATUN.

APPARATUS USED TO DETERMINE FRICTIONAL RESISTANCE TO WATER OF SOILS IN THE VICINITY OF GATUN.

Plate 64.

WEST SIDE OF EXPERIMENTAL TANK USED IN TESTING MODEL DAM.

INTAKE PIPE AND VALVES USED IN EXPERIMENTAL TANK FOR MODEL DAM.

INSIDE OF EXPERIMENTAL TANK DURING CONSTRUCTION OF MODEL DAM.

PLATE 67.

EAST SIDE OF EXPERIMENTAL TANK USED IN TESTING MODEL DAM.

PLATE 68.

PUMPING MATERIAL FROM BARGE INTO EXPERIMENTAL TANK FOR CONSTRUCTION OF MODEL DAM.

METHOD OF DISCHARGING MATERIAL INTO EXPERIMENTAL TANK IN CONSTRUCTING MODEL DAM.

SURFACE CONDITIONS AT MOUTH OF TEST PIT ON GATUN ISLAND.

PLATE 71.

METHOD OF BRACING TEST PIT ON GATUN ISLAND.

KEYSTONE DRILL AT WORK, GATUN DAM SITE.

PLATE 73.

CLAY AND ROTTEN WOOD, EL. −25.

BLUE SANDY CLAY, EL. −48.

CORES FROM KEYSTONE DRILL AT WORK ON GATUN DAM SITE, FULL SIZE. HOLE NO. 1082.

PLATE 74.

WASH SAMPLE AT EL. −194.4. DRIVE SAMPLE AT EL. −194.4. DRIVE SAMPLE AT EL. −207.4. WASH SAMPLE AT EL. −207.4.

COMPARISON BETWEEN WASH AND DRIVE SAMPLES TAKEN BY WASH DRILL, FULL SIZE. HOLE NO 1088.

PLATE 75.

WASH SAMPLE AT EL. −186 6 | DRIVE SAMPLE AT EL. −186.6. | DRIVE SAMPLE AT EL. −181.1. | WASH SAMPLE AT EL. −188.1.

COMPARISON BETWEEN WASH AND DRIVE SAMPLES TAKEN BY WASH DRILL, FULL SIZE. HOLES NOS. 1087 AND 1089.

PLATE 76.

WASH DRILL GANG AT WORK.

Plate 77.

DIAMOND DRILL AT WORK.

PLATE 78.

ARGILLACEOUS SANDSTONE. RHYOLITE.

SAMPLES OF DIAMOND DRILL CORES, FULL SIZE.

CONGLOMERATE. ARGILLACEOUS SANDSTONE WITH TUFA.

SAMPLES OF DIAMOND DRILL CORES, FULL SIZE.

Plate 80.

SAMPLES OF DIAMOND DRILL CORES, FULL SIZE. HOLE NO. 1064, EL. -32.

RHYOLITE AS IN PLACE.

CONGLOMERATE AS IN PLACE.

SAMPLES OF ROCK FROM VICINITY OF GATUN, FULL SIZE.

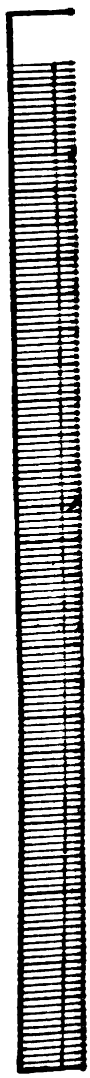
PLATE 83.

ARGILLA[C]ROM ISLAND TEST PIT.

PLATE 84.

PLATE 85.

SHOWING JOINT PLANES AND ISSUING STREAM.



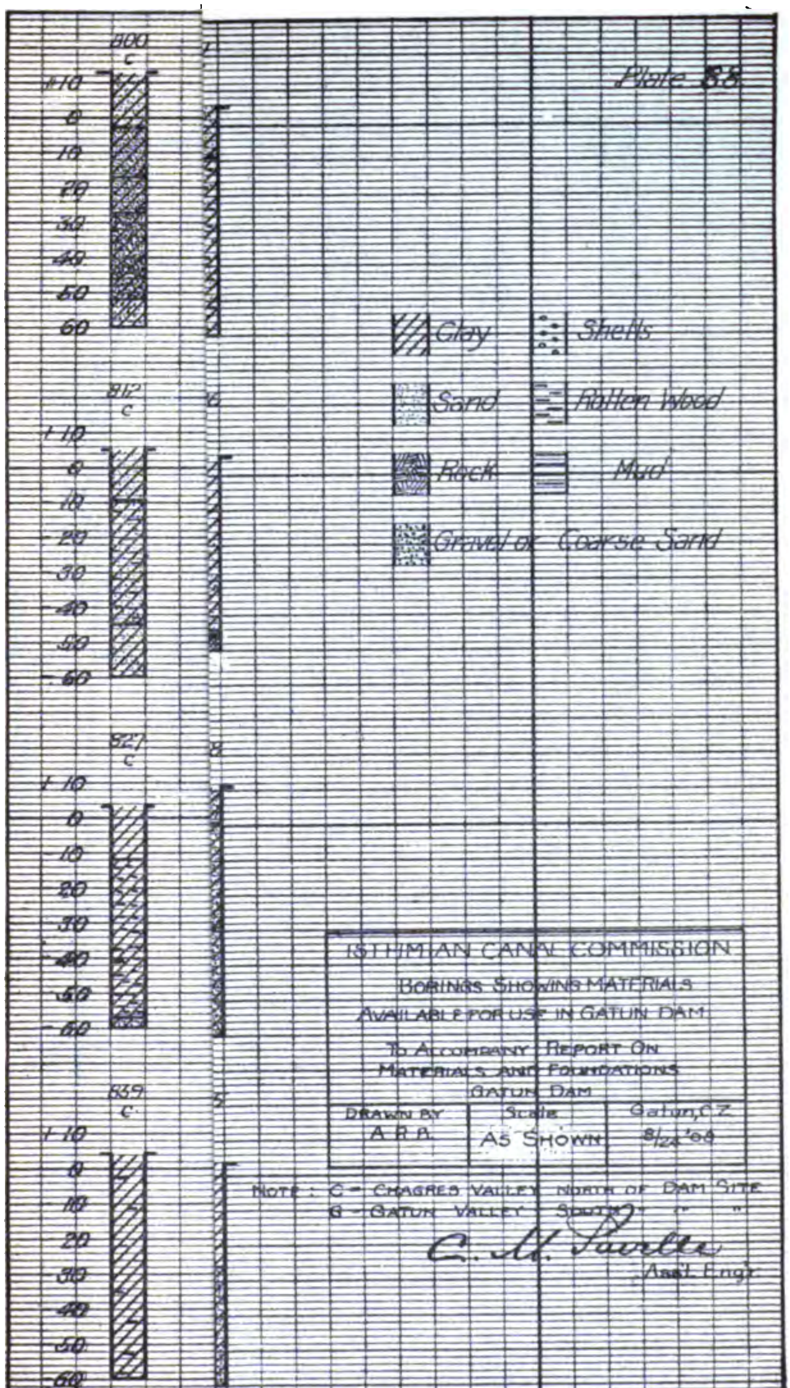


Plate 88
800 C
812 C
827 C
839 C
Clay
Shells
Sand
Rotten Wood
Rock
Mud
Gravel or Coarse Sand
ISTHMIAN CANAL COMMISSION
BORINGS SHOWING MATERIALS
AVAILABLE FOR USE IN GATUN DAM
TO ACCOMPANY REPORT ON
MATERIALS AND FOUNDATIONS
GATUN DAM
DRAWN BY
A.R.B.
Scale
AS SHOWN
Gatun, C.Z.
8/24 '08
NOTE: C - CHAGRES VALLEY NORTH OF DAM SITE
G - GATUN VALLEY SOUTH " " "
C. M. Saville
Ass't Eng'r.

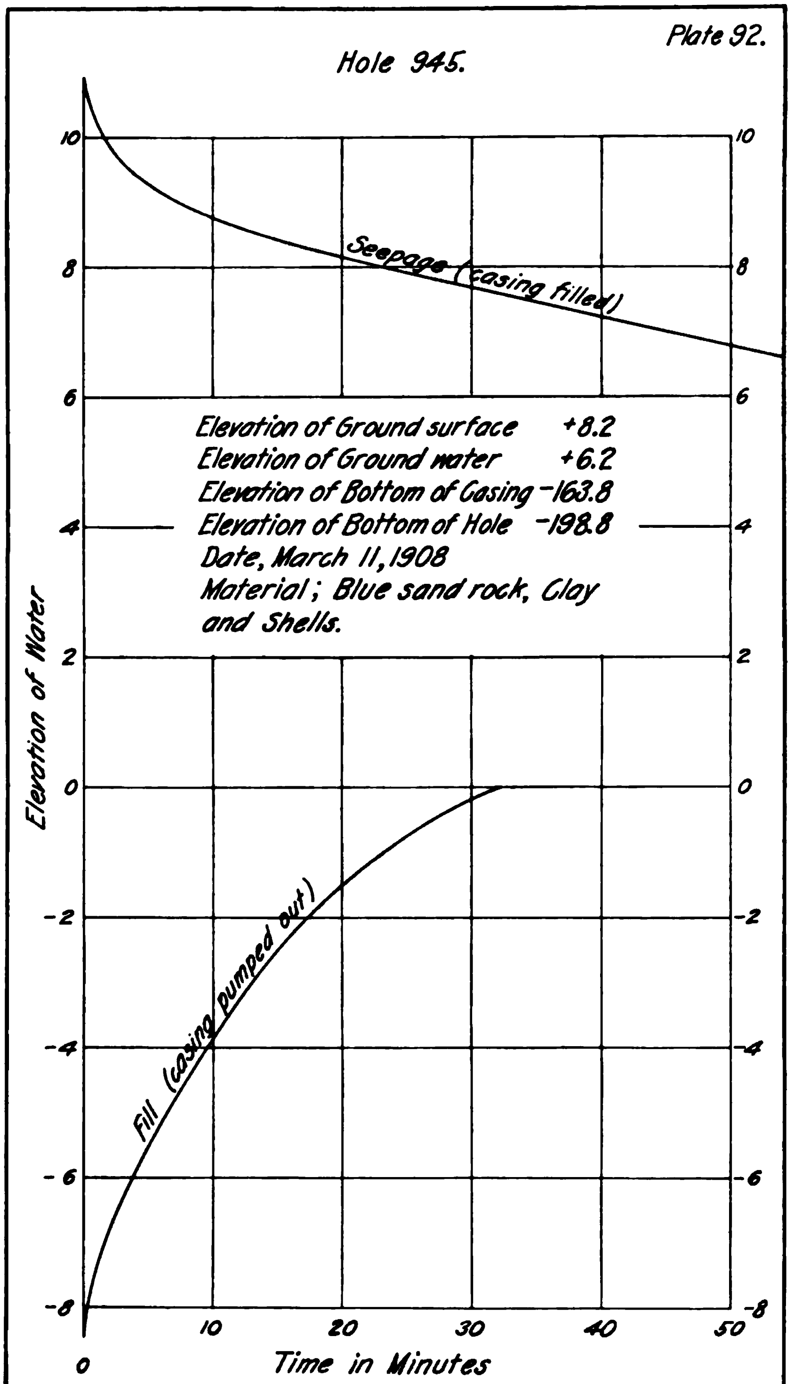
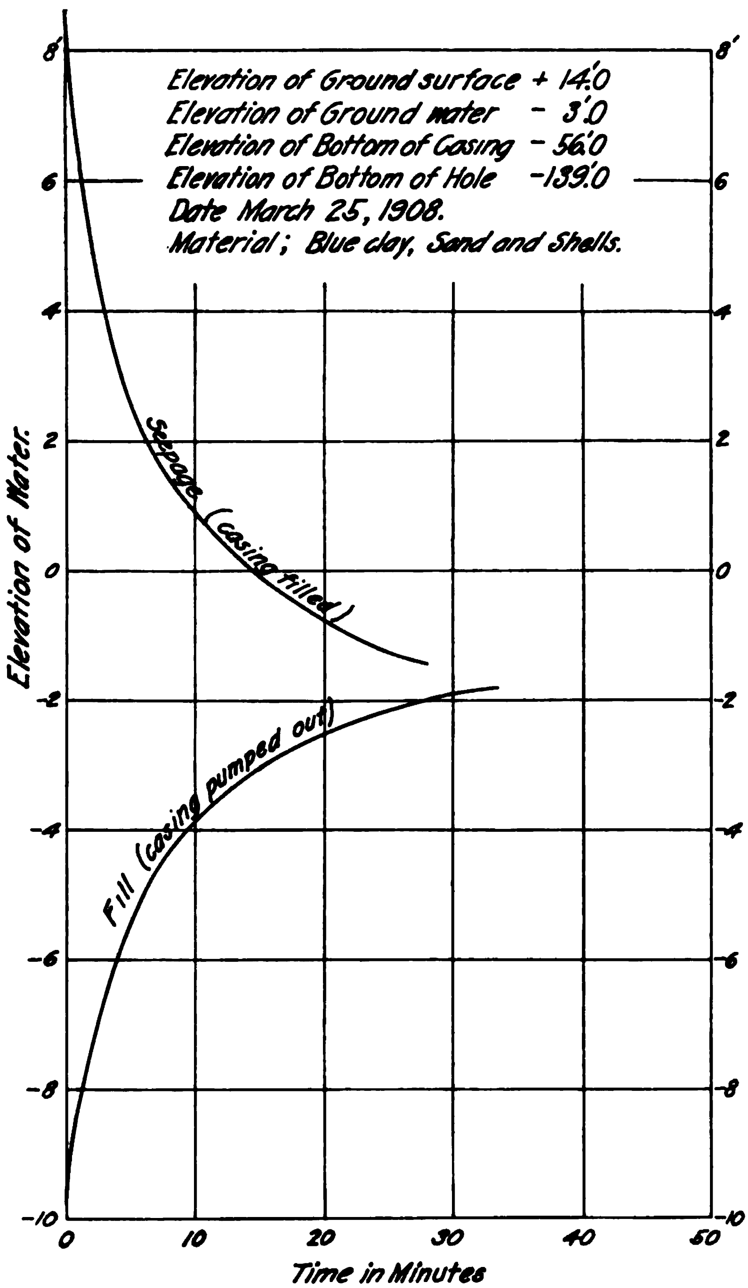


Plate 92.
Hole 945.
Seepage (casing filled)
Elevation of Ground surface +8.2
Elevation of Ground water +6.2
Elevation of Bottom of Casing -163.8
Elevation of Bottom of Hole -198.8
Date, March 11, 1908
Material; Blue sand rock, Clay and Shells.
Fill (casing pumped out)
Elevation of Water
Time in Minutes
10
8
6
4
2
0
-2
-4
-6
-8
0
10
20
30
40
50

Plate 93

Hole 948



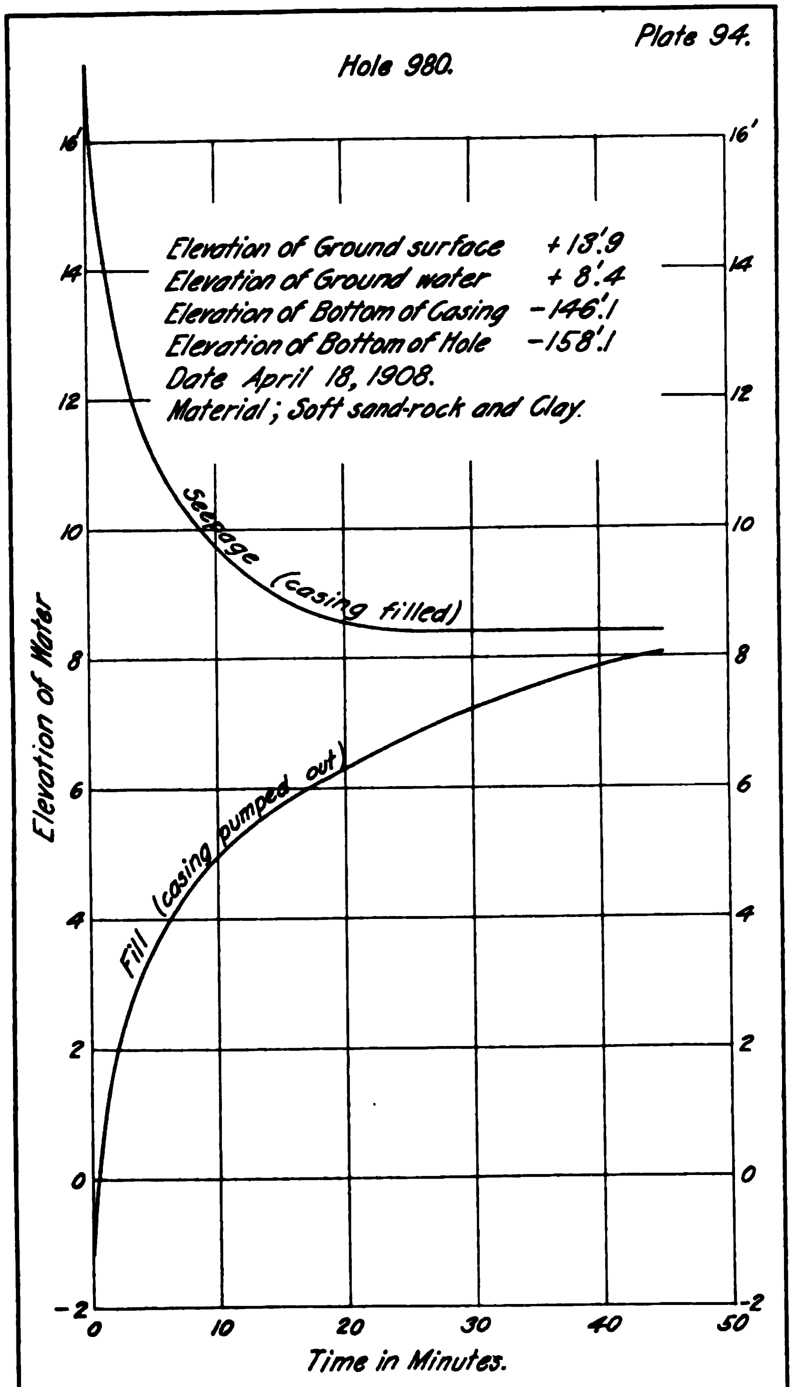
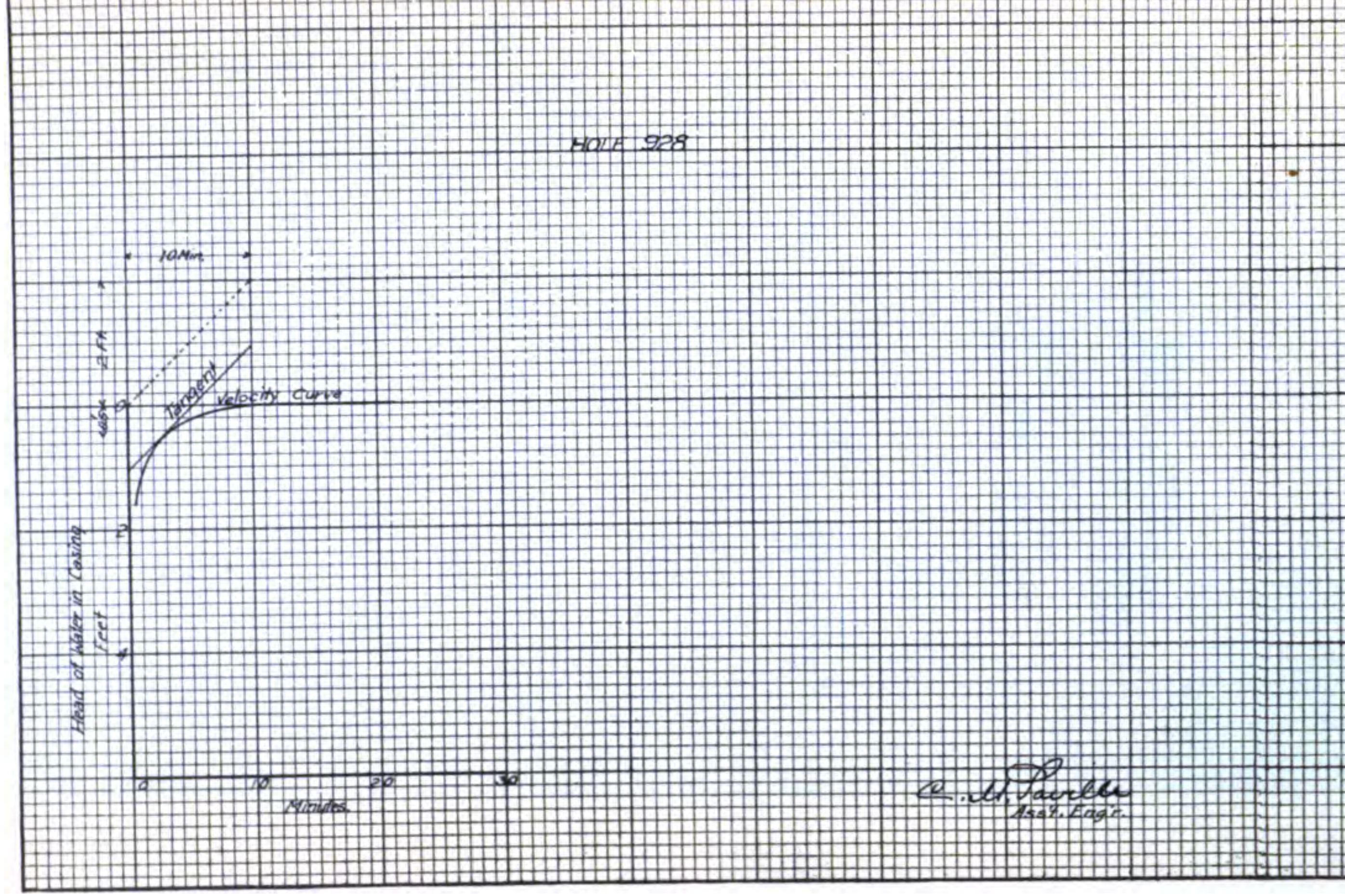


Plate 94.
Hole 980.
Elevation of Ground surface +18'.9
Elevation of Ground water + 8'.4
Elevation of Bottom of Casing -146'.1
Elevation of Bottom of Hole -158'.1
Date April 18, 1908.
Material; Soft sand-rock and Clay.
Seepage (casing filled)
Fill (casing pumped out)
Elevation of Water
Time in Minutes.
16 14 12 10 8 6 4 2 0 -2
16' 14 12 10 8 6 4 2 0 -2
0 10 20 30 40 50

Plate 95.


HOLE 928
10 Min.
2 Ft.
Tangent
Velocity Curve
Head of Water in Casing
Feet
0
2
4
0
10
20
30
Minutes.
Ass't. Eng'r.

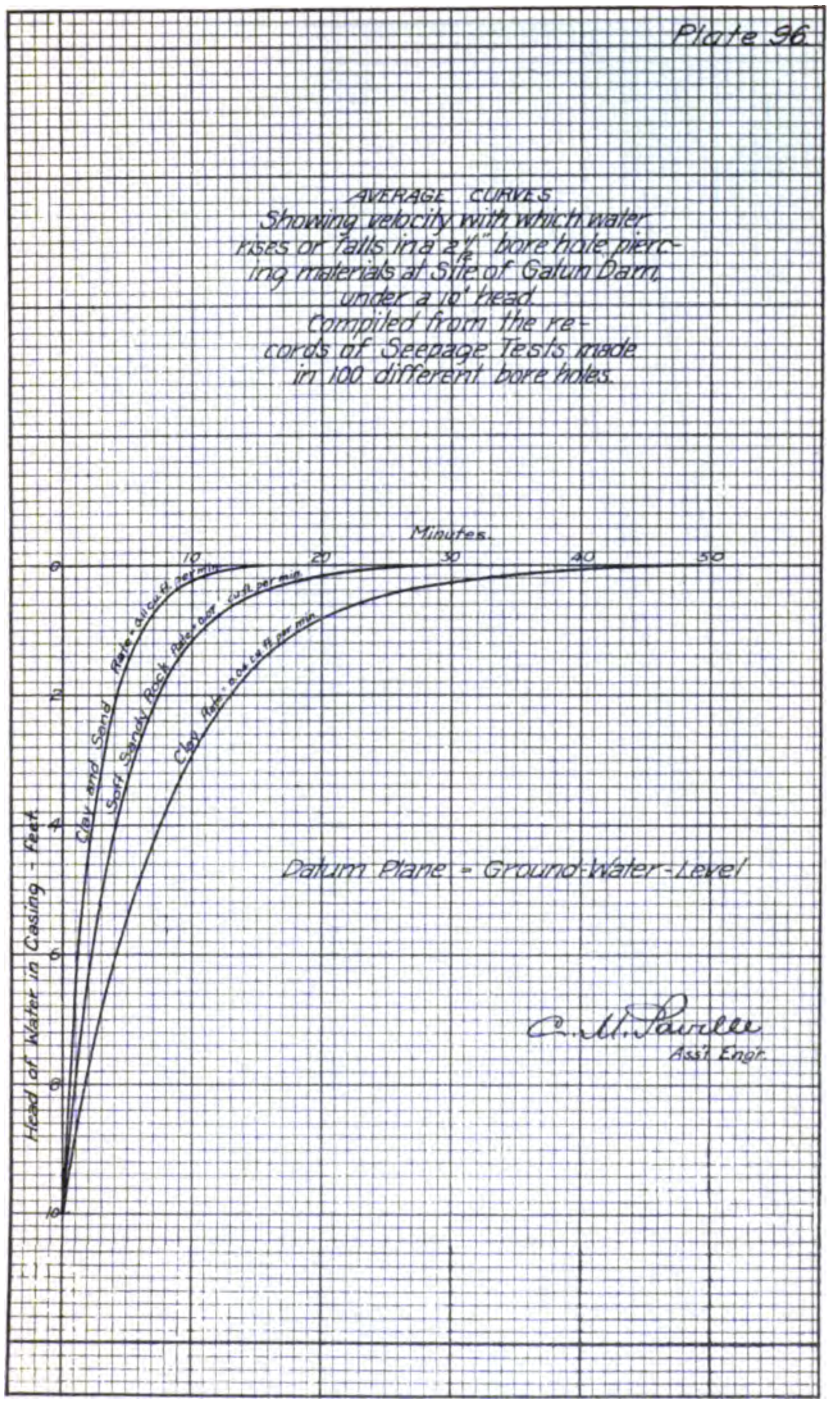


Plate 96
AVERAGE CURVES
Showing velocity with which water rises or falls in a 2¼" bore hole piercing materials at Site of Gatun Dam, under a 10' head
Compiled from the records of Seepage Tests made in 100 different bore holes.
Minutes.
10
20
30
40
50
0
2
4
6
8
10
Head of Water in Casing - Feet
Clay and Sand Rate = 0.11 cu ft. per min
Soft Sandy Rock Rate = 0.07 cu ft. per min
Clay Rate = 0.04 cu ft. per min
Datum Plane = Ground-Water-Level
Ass't Engr.

Plate 97

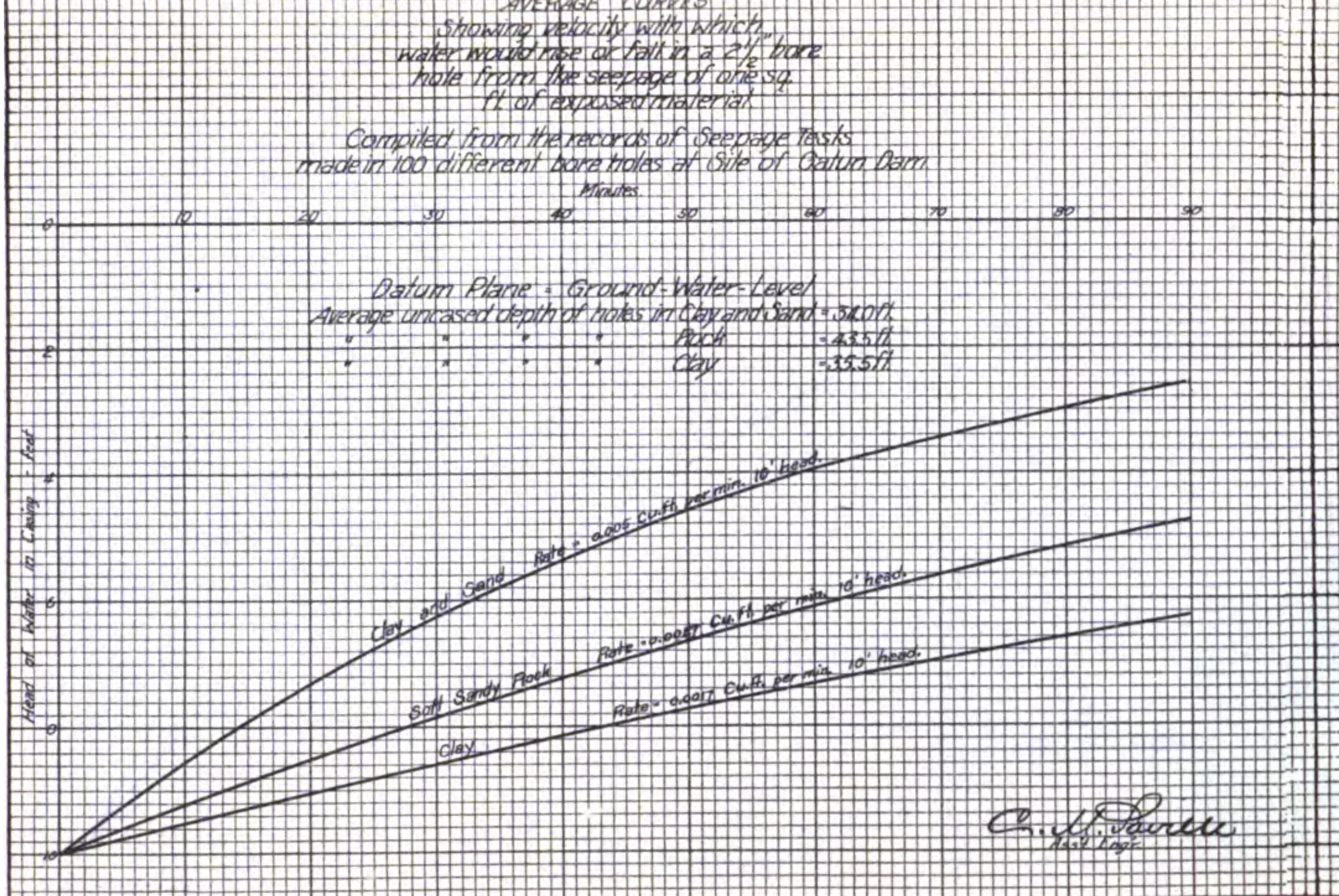

AVERAGE CURVES
Showing velocity with which water would rise or fall in a 2½" bore hole from the seepage of one sq. ft. of exposed material.
Compiled from the records of Seepage Tests made in 100 different bore holes at Site of Gatun Dam.
Minutes
0
10
20
30
40
50
60
70
80
90
Datum Plane = Ground-Water-Level
Average uncased depth of holes in Clay and Sand = 34.0 ft.
" " " " Rock = 43.5 ft.
" " " " Clay = 35.5 ft.
Clay and Sand Rate = 0.005 Cu.ft. per min. 10' head.
Soft Sandy Rock Rate = 0.0037 Cu.ft. per min. 10' head.
Clay Rate = 0.0017 Cu.ft. per min. 10' head.
Head of Water in Casing - Feet
0
2
4
6
8
10
Asst. Engr.

Plate 98.

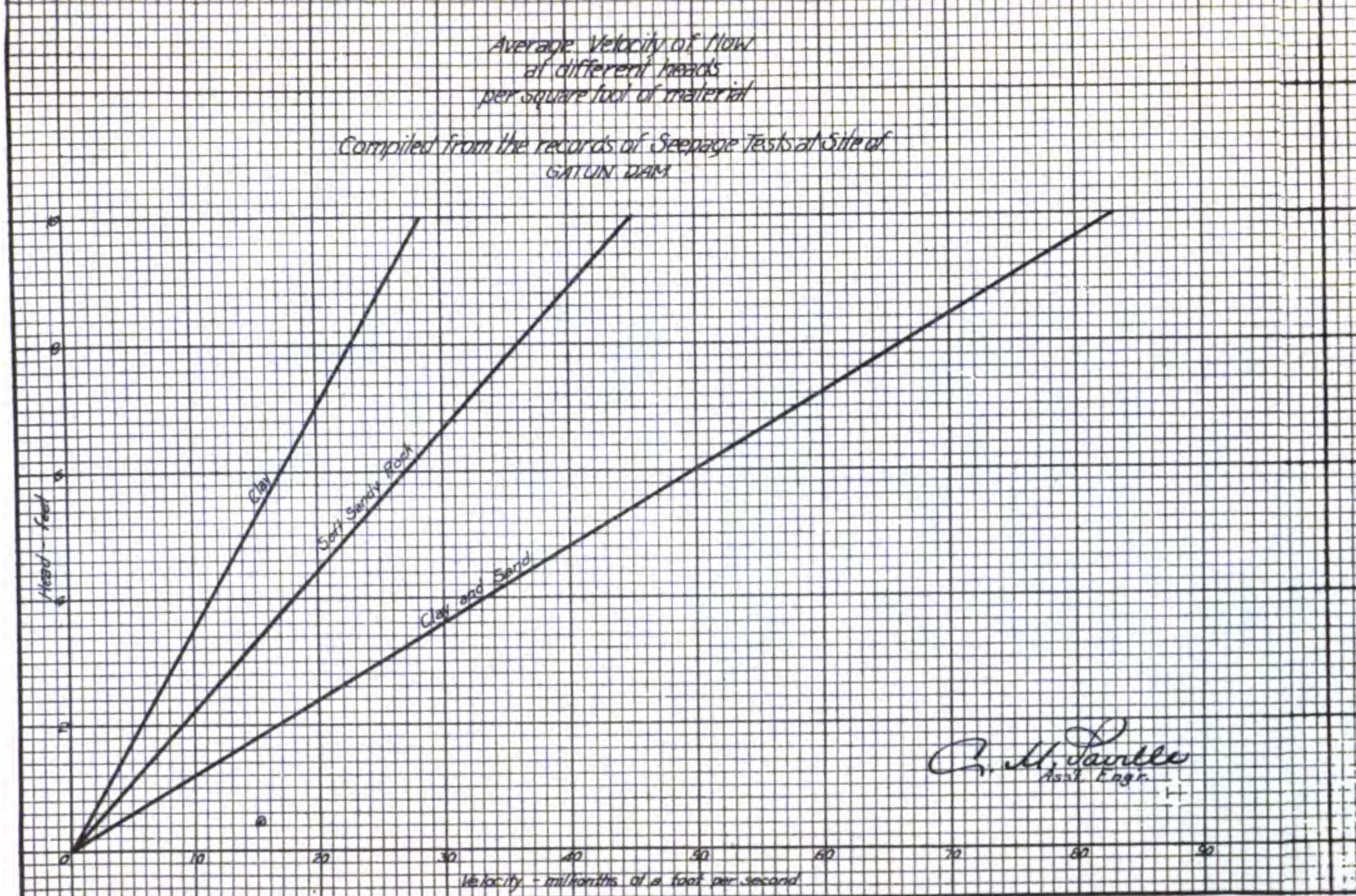
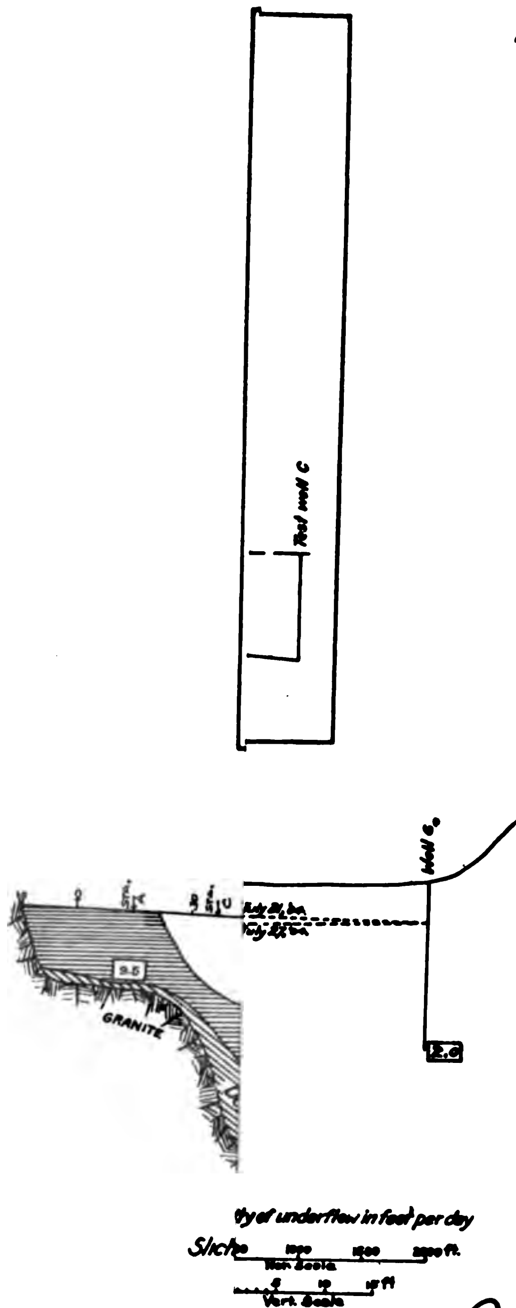

Average Velocity of flow
at different heads
per square foot of material
Compiled from the records of Seepage Tests at Site of
GATUN DAM
Clay
Soft Sandy Rock
Clay and Sand
Head - Feet
0
2
4
6
8
10
10
20
30
40
50
60
70
80
90
Velocity - millionths of a foot per second
C. M. Saville
Asst. Engr.

Plate 100



C. M. Saville
Ass't Eng'r

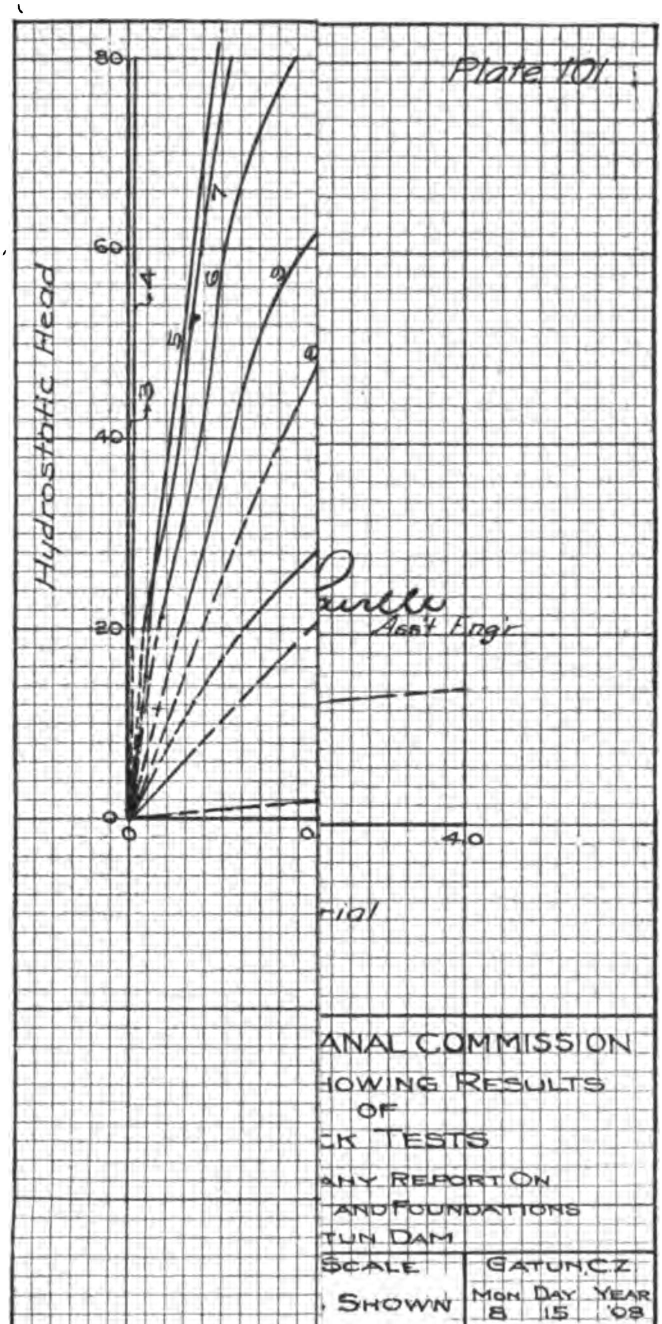


Plate 101
Hydrostatic Head
80
60
40
20
0
0
0
40
7
6
5
4
3
2
Asst Eng'r
rial
ANAL COMMISSION
HOWING RESULTS
OF
CK TESTS
ANY REPORT ON
AND FOUNDATIONS
TUN DAM
SCALE
SHOWN
GATUN, C.Z.
MON DAY YEAR
8 15 '08

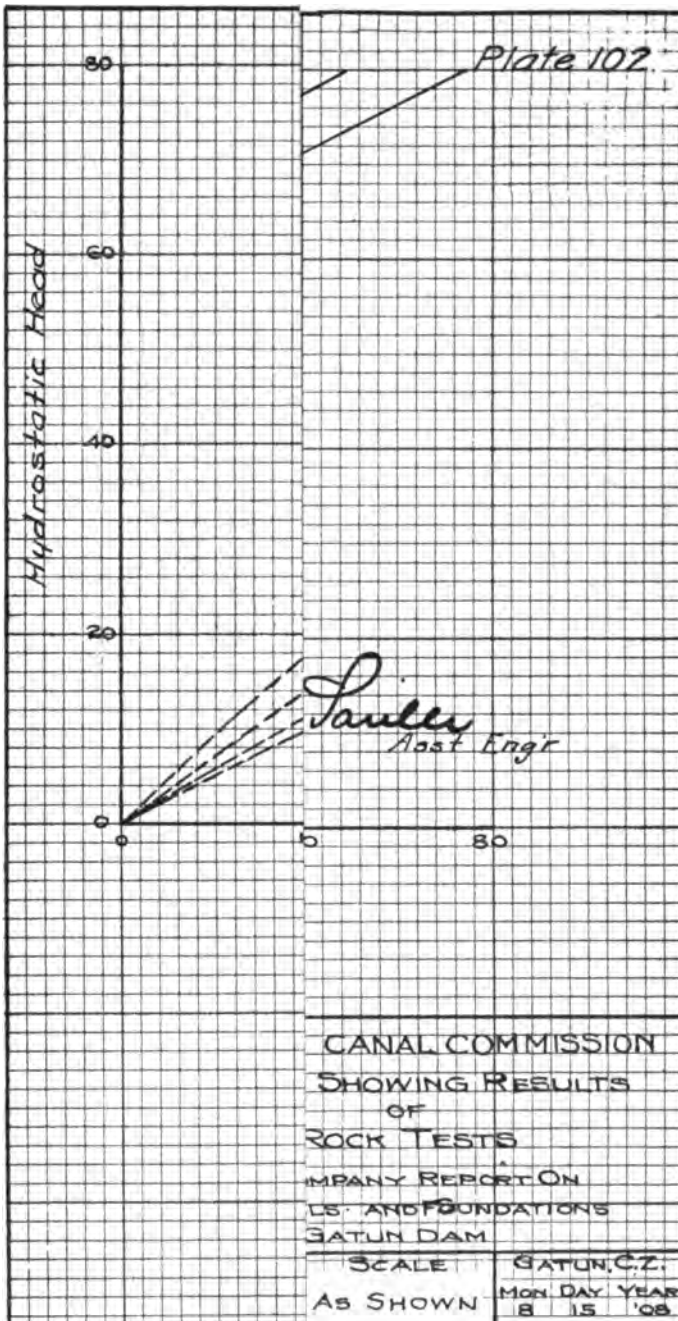


Plate 102
Hydrostatic Head
80
60
40
20
0
0
80
Aast Eng'r
CANAL COMMISSION
SHOWING RESULTS
OF
ROCK TESTS
MPANY REPORT ON
LS AND FOUNDATIONS
GATUN DAM
SCALE
AS SHOWN
GATUN, C.Z.
MON DAY YEAR
8 15 '08

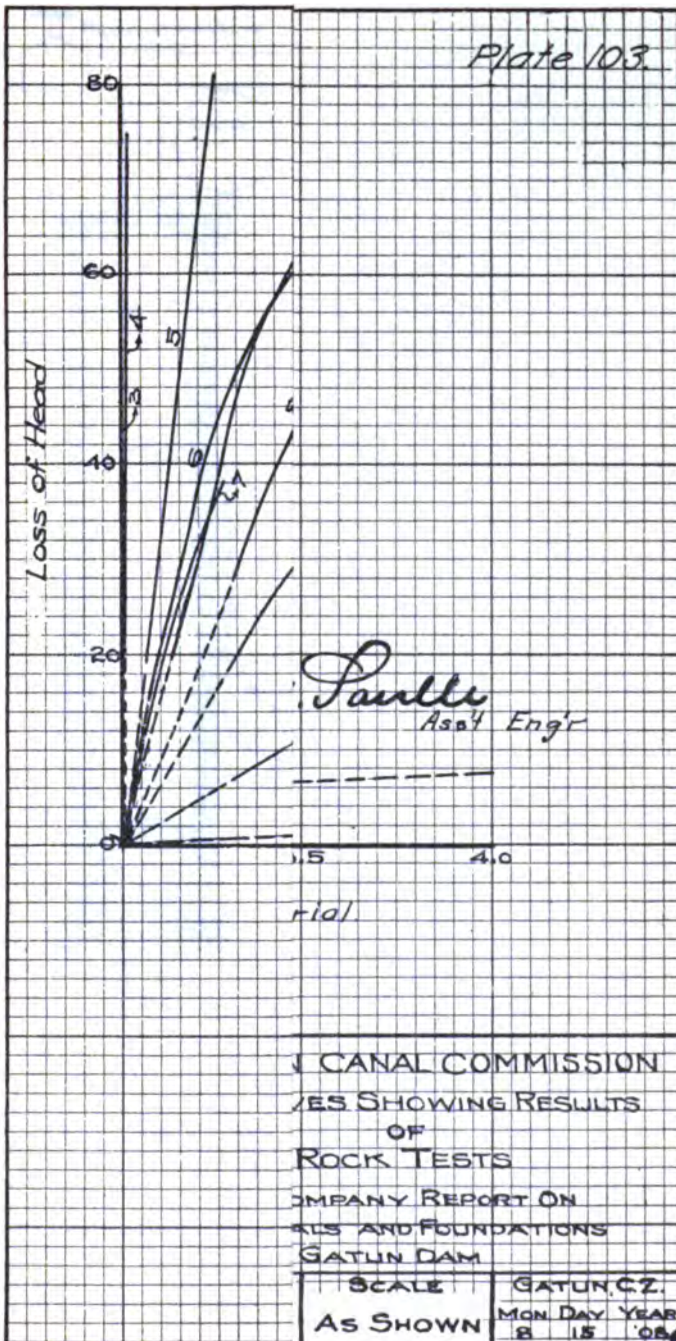


Plate 103.
80
60
40
20
0
Loss of Head
.5
4.0
rial
Ass't Eng'r
CANAL COMMISSION
ES SHOWING RESULTS
OF
ROCK TESTS
MPANY REPORT ON
LS AND FOUNDATIONS
GATUN DAM
SCALE
AS SHOWN
GATUN C.Z.
MON DAY YEAR
8 15 '08

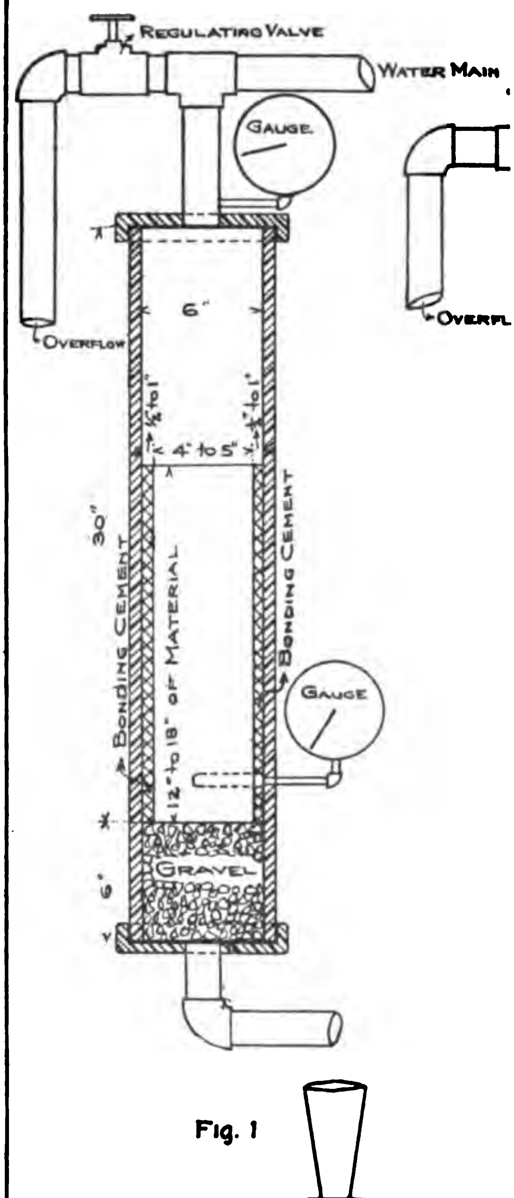


Fig. 1

For Permeability Tests

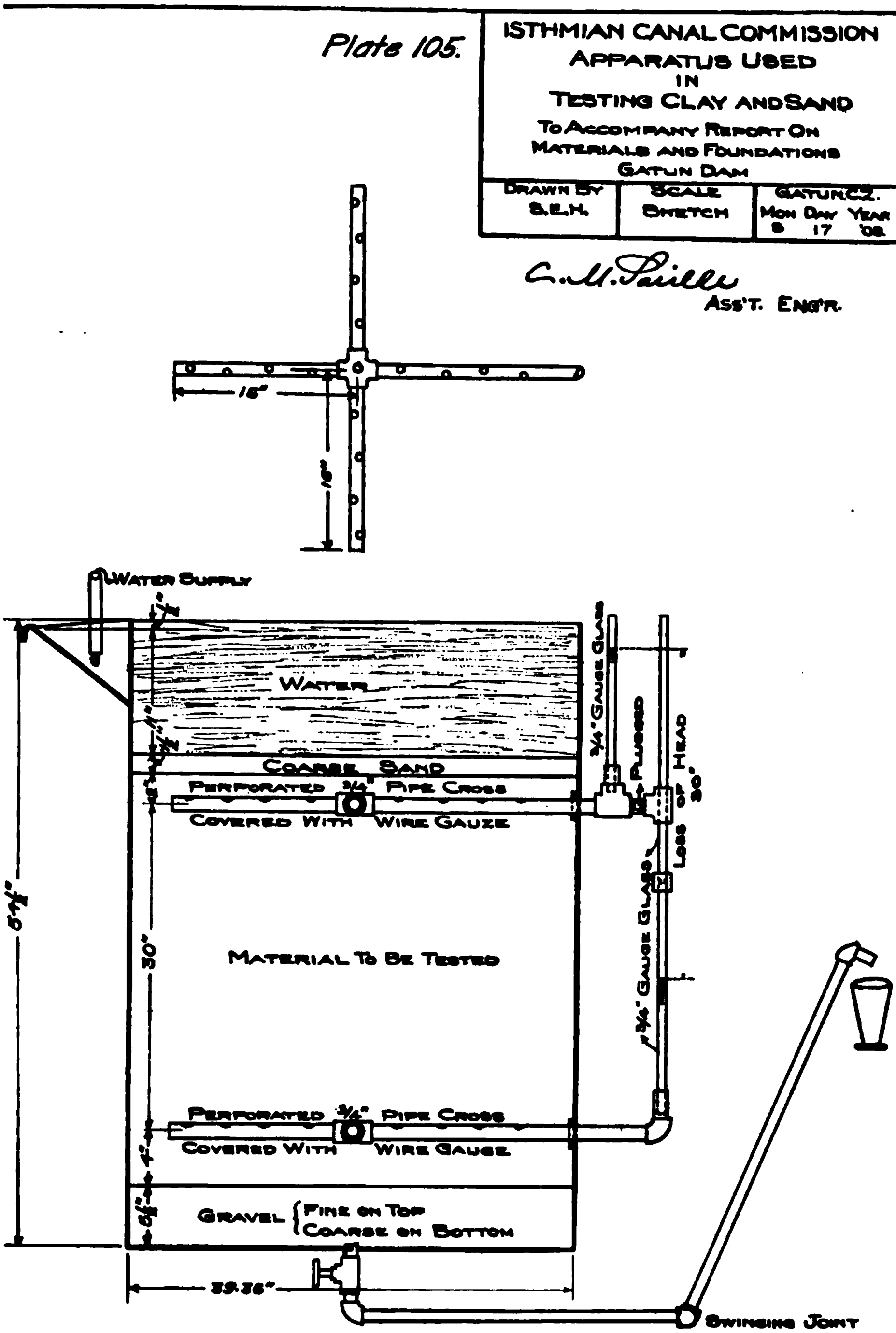
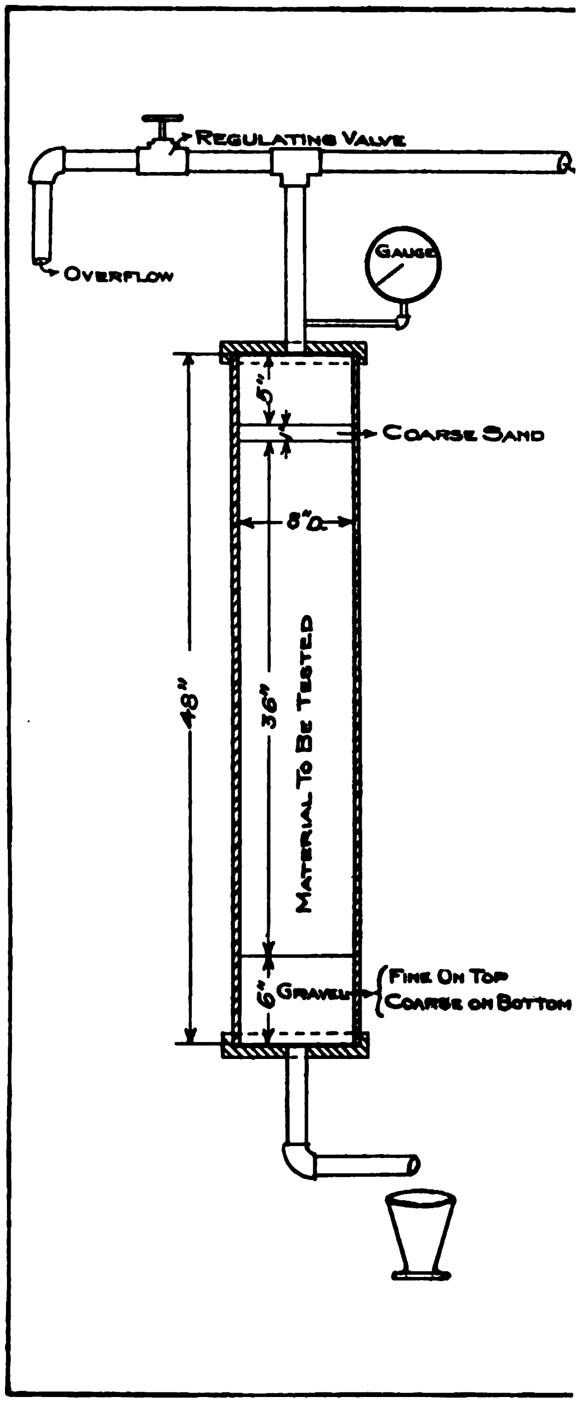
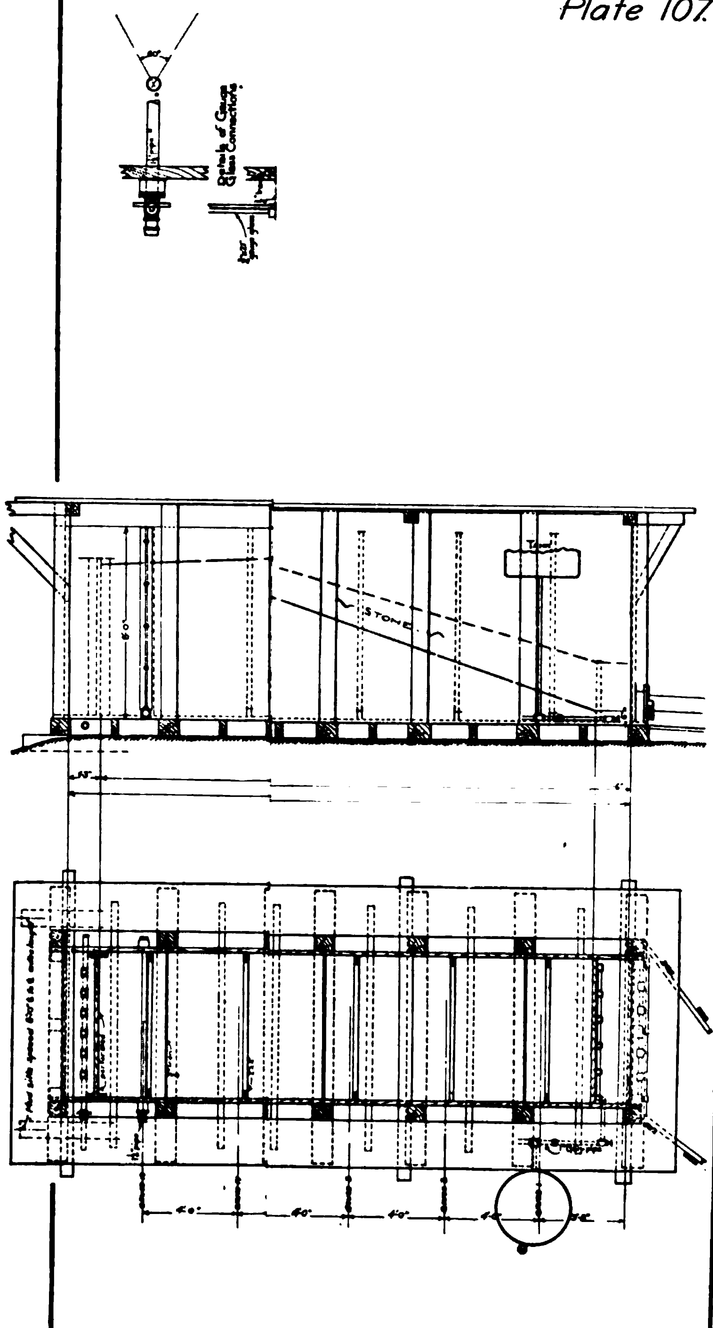


Plate 105.
ISTHMIAN CANAL COMMISSION
APPARATUS USED
IN
TESTING CLAY AND SAND
TO ACCOMPANY REPORT ON
MATERIALS AND FOUNDATIONS
GATUN DAM
DRAWN BY S.E.H.
SCALE SKETCH
GATUN C.Z. MON DAY YEAR 8 17 '08.
C. M. Saville
ASS'T. ENG'R.
15"
15"
WATER SUPPLY
WATER
COARSE SAND
PERFORATED 3/4" PIPE CROSS
COVERED WITH WIRE GAUZE
MATERIAL TO BE TESTED
PERFORATED 3/4" PIPE CROSS
COVERED WITH WIRE GAUZE
GRAVEL { FINE ON TOP
COARSE ON BOTTOM
3/4" GAUGE GLASS
PLUGGED
LOSS OF HEAD 30"
3/4" GAUGE GLASS
5' 4½"
30"
4"
8½"
39.36"
SWINGING JOINT



Regulating Valve
Overflow
Gauge
5"
Coarse Sand
8"D.
48"
36"
Material To Be Tested
6"
Gravel
Fine On Top
Coarse on Bottom

Plate 107.



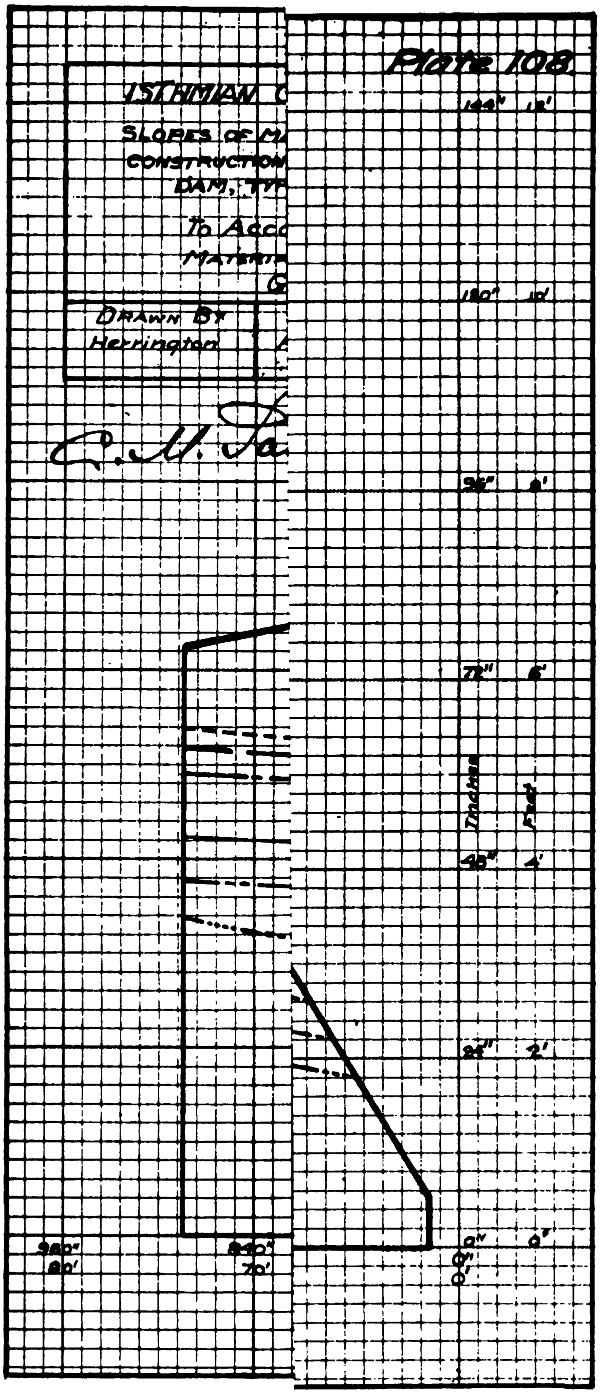
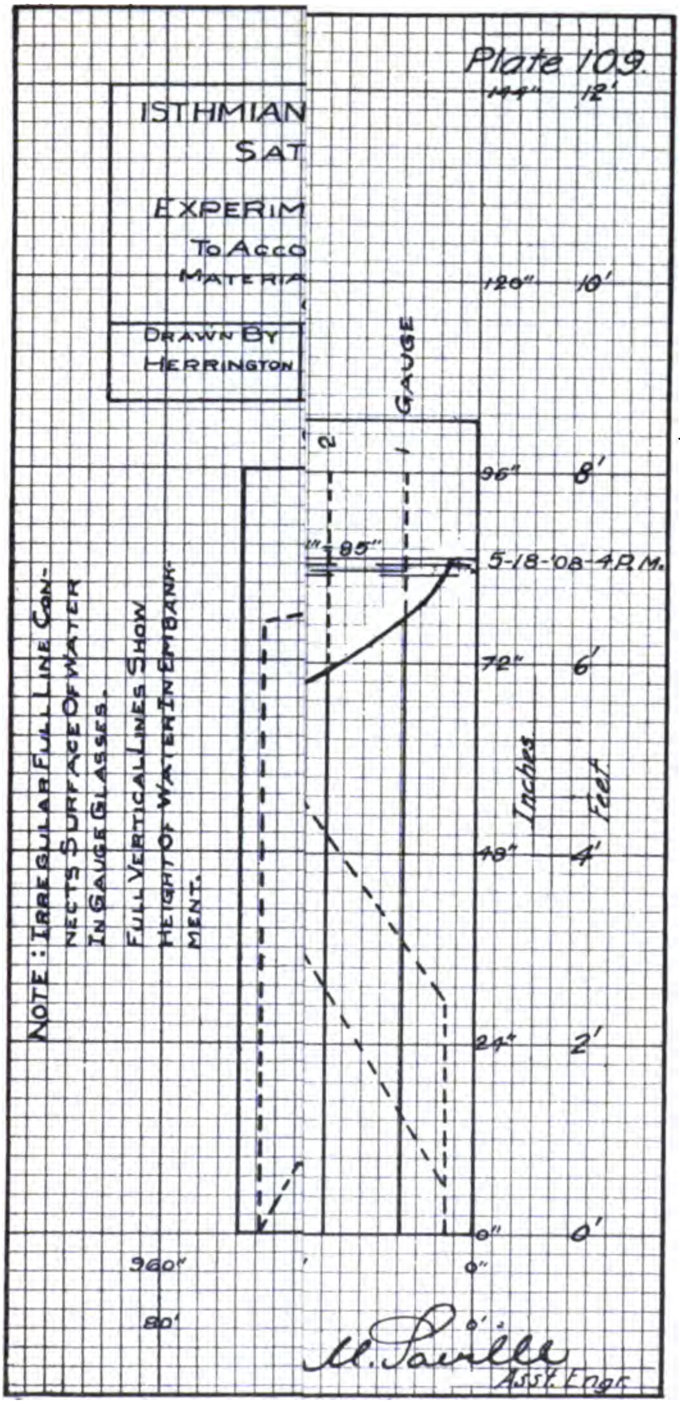


Plate 108
ISTHMIAN C
SLOPES OF M
CONSTRUCTION
DAM, TY
To Acco
MATERIA
DRAWN BY
Herrington
144" 12'
120" 10'
96" 8'
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
960"
80'
840"
70'

Plate 109.



ISTHMIAN
SAT
EXPERIM
To Acco
Materia
Drawn By
Herrington
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches
Feet
GAUGE
2
1
85"
5-18-'08-4 P.M.
NOTE: Irregular Full Line Connects Surface of Water In Gauge Glasses.
Full Vertical Lines Show Height of Water In Embankment.
960"
80'
0"
0'
M. Saville
Ass't. Engr.

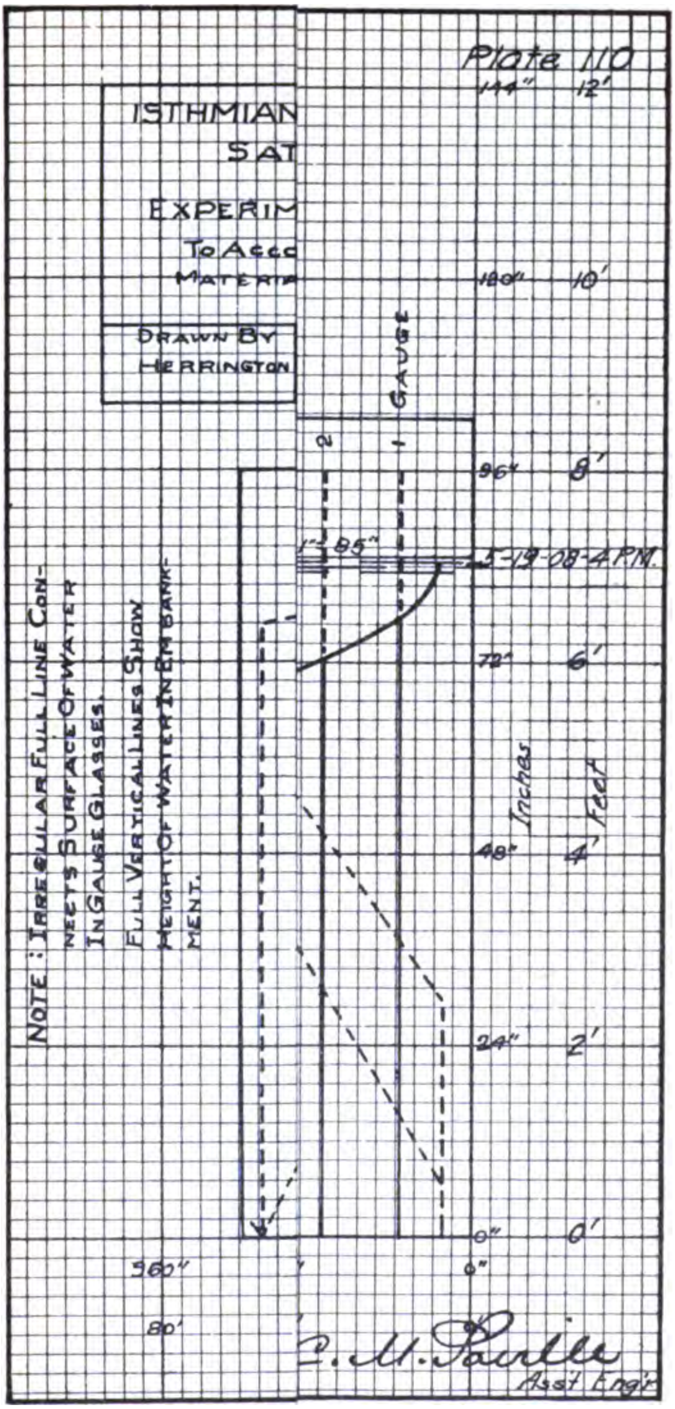


Plate 110
144" 12'
ISTHMIAN
SAT
EXPERIM
To Acco
MATERIA
DRAWN BY
HERRINGTON
GAUGE
2
1
120" 10'
96" 8'
5-19-08-4 P.M.
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
360"
0"
80'
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
Asst Eng'r

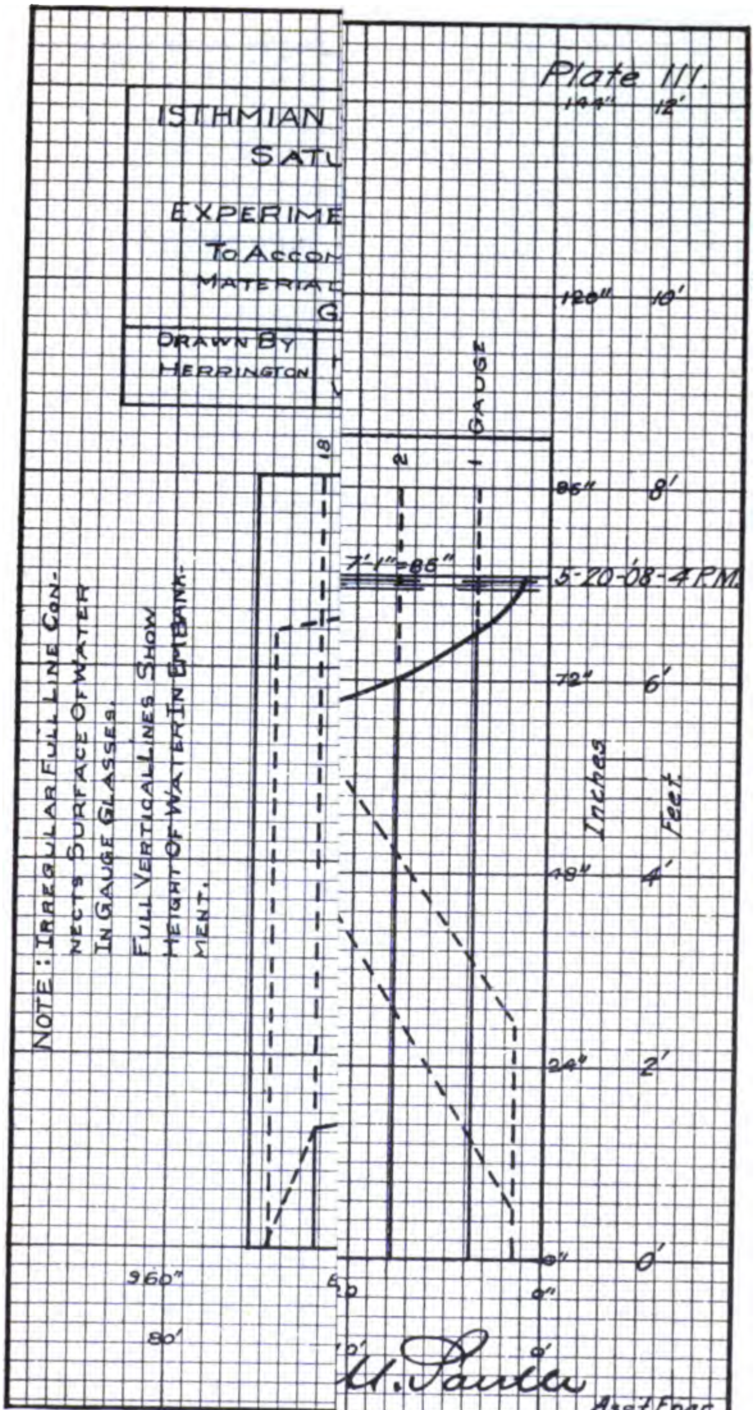


Plate III.
ISTHMIAN
SATU
EXPERIME
To Accom
Material
G
Drawn By
Herrington
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
7'1"=85"
5-20-08-4 P.M.
Gauge
Inches
Feet
NOTE: Irregular Full Line Connects Surface Of Water In Gauge Glasses.
Full Vertical Lines Show Height Of Water In Embankment.
960"
80'
Asst Engr.

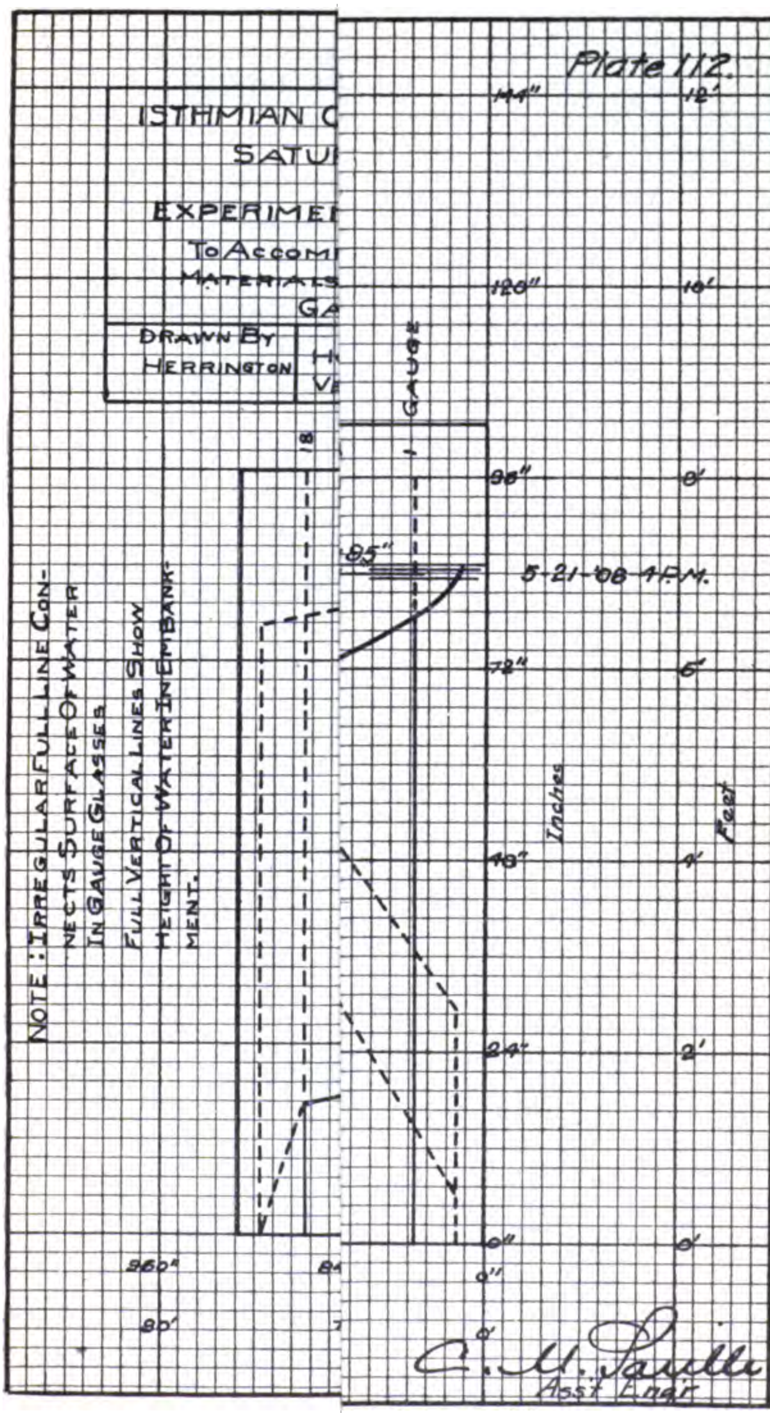


Plate 112.
ISTHMIAN C
SATU
EXPERIMEN
To Accom
Materials
Ga
Drawn By
Herrington
Gauge
18
85"
5-21-'08 1 P.M.
144"
12'
120"
10'
96"
8'
72"
6'
48"
4'
24"
2'
0"
0'
Inches
Feet
960"
80'
Note: Irregular Full Line Connects Surface Of Water In Gauge Glasses
Full Vertical Lines Show Height Of Water In Embankment.
Asst Engr

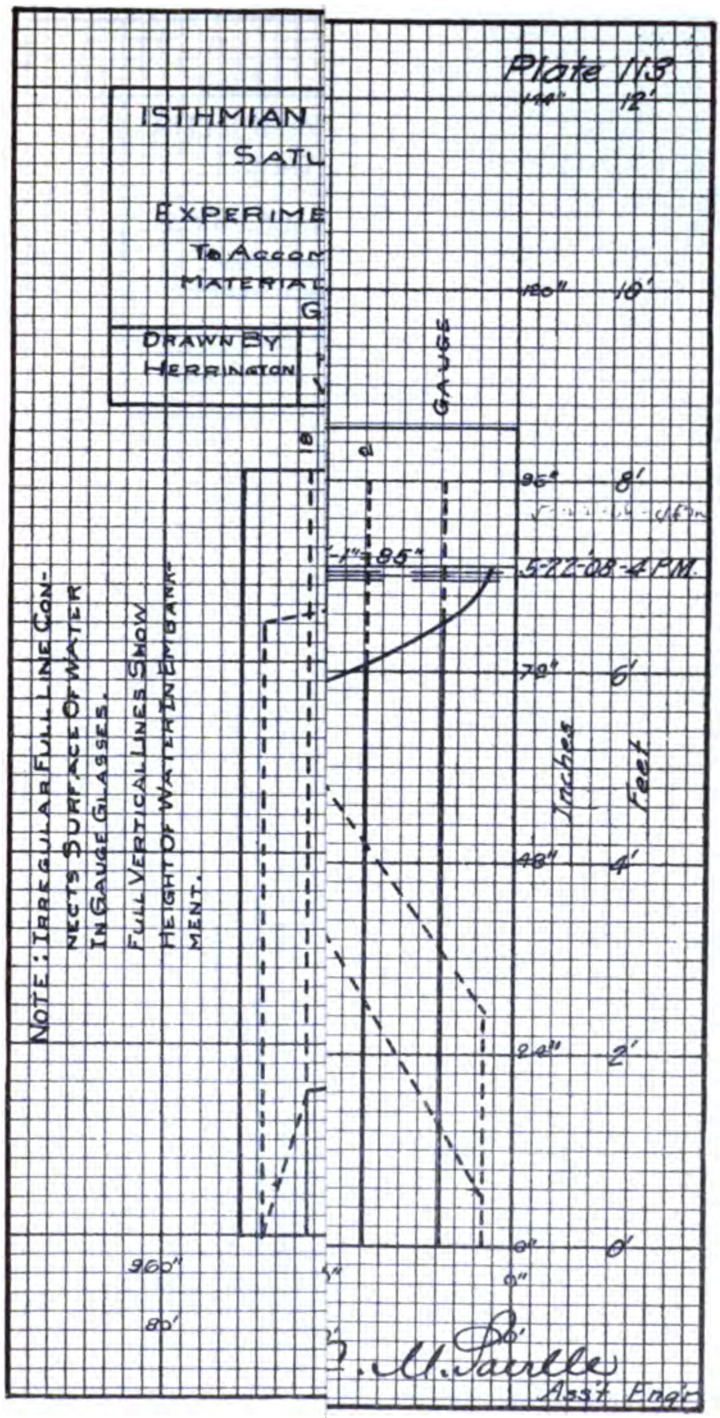


Plate 113
ISTHMIAN
SATL
EXPERIME
To Accom
MATERIAL
G
DRAWN BY
HERRINGTON
GAUGE
144" 12'
120" 10'
96" 8'
5-22-08-4 PM.
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
960"
80'
0"
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
Ass't Engr.

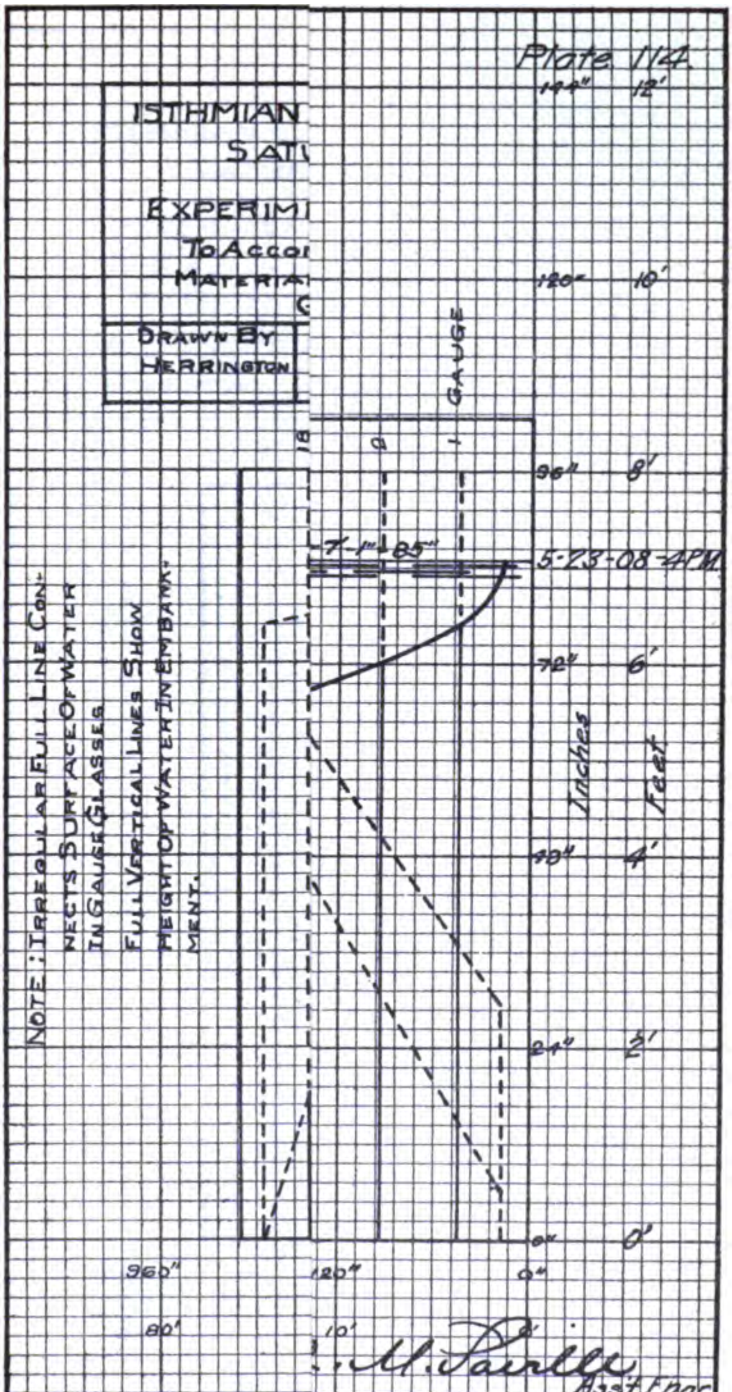


Plate 114
ISTHMIAN
SAT
EXPERIM
To Acco
MATERIA
DRAWN BY
HERRINGTON
GAUGE
18
0
1
144" 12'
120" 10'
96" 8'
7-1"
85"
5-23-08-4PM
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
960"
120"
0"
80'
10'
0'
Asst Engr.

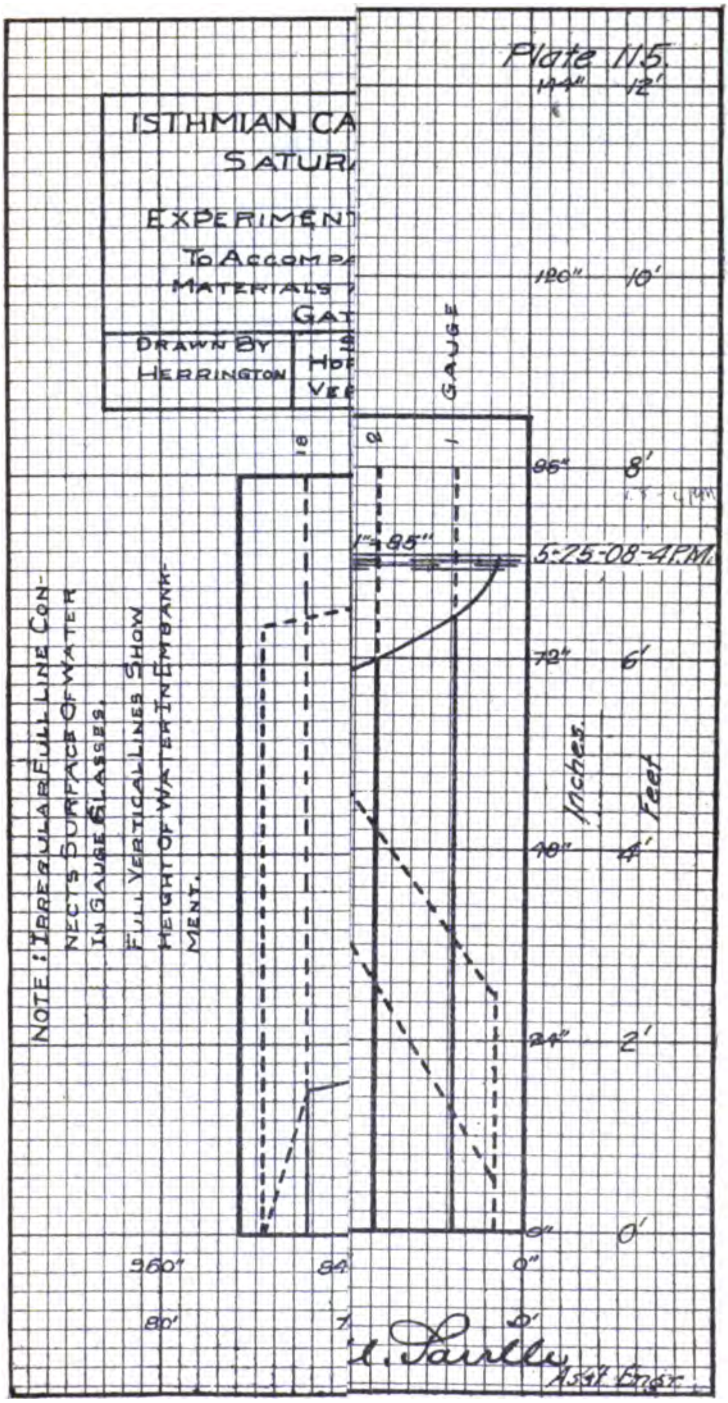


Plate N.5.
ISTHMIAN CA
SATUR
EXPERIMENT
To Accompa
Materials
Gat
Drawn By
Herrington
GAUGE
NOTE: Irregular Full Line Connects Surface of Water in Gauge Glasses.
Full Vertical Lines Show Height of Water in Embankment.
5-25-08-4P.M.
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches.
Feet
960"
80'
0"
0'
Ass't Engr.

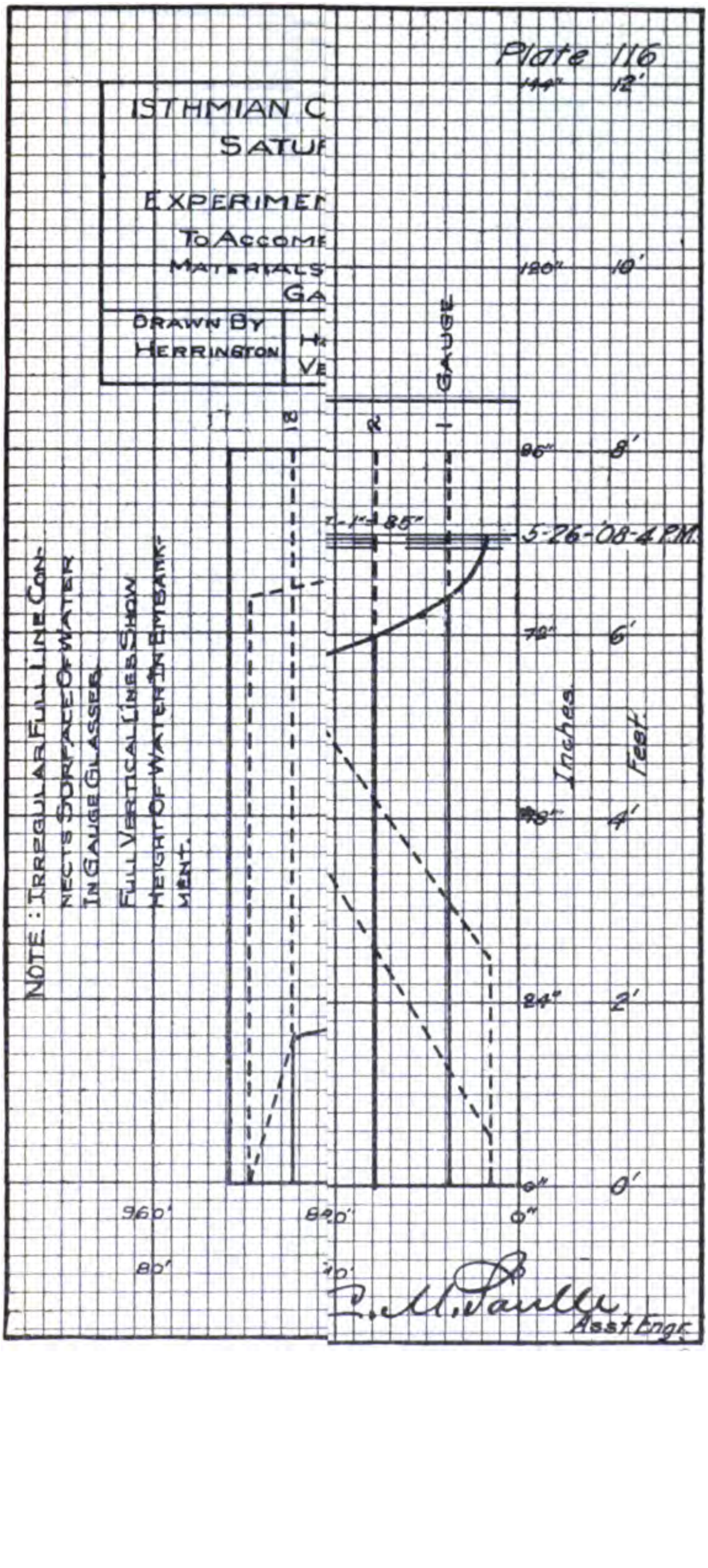


Plate 116
ISTHMIAN C
SATUR
EXPERIMEN
To Accomp
Materials
Ga
Drawn By
Herrington
H
Ve
Gauge
18
2
1
144" 12'
120" 10'
96" 8'
7-1"-85"
5-26-08-4 P.M.
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
960'
840'
0"
80'
40'
Asst Engr.

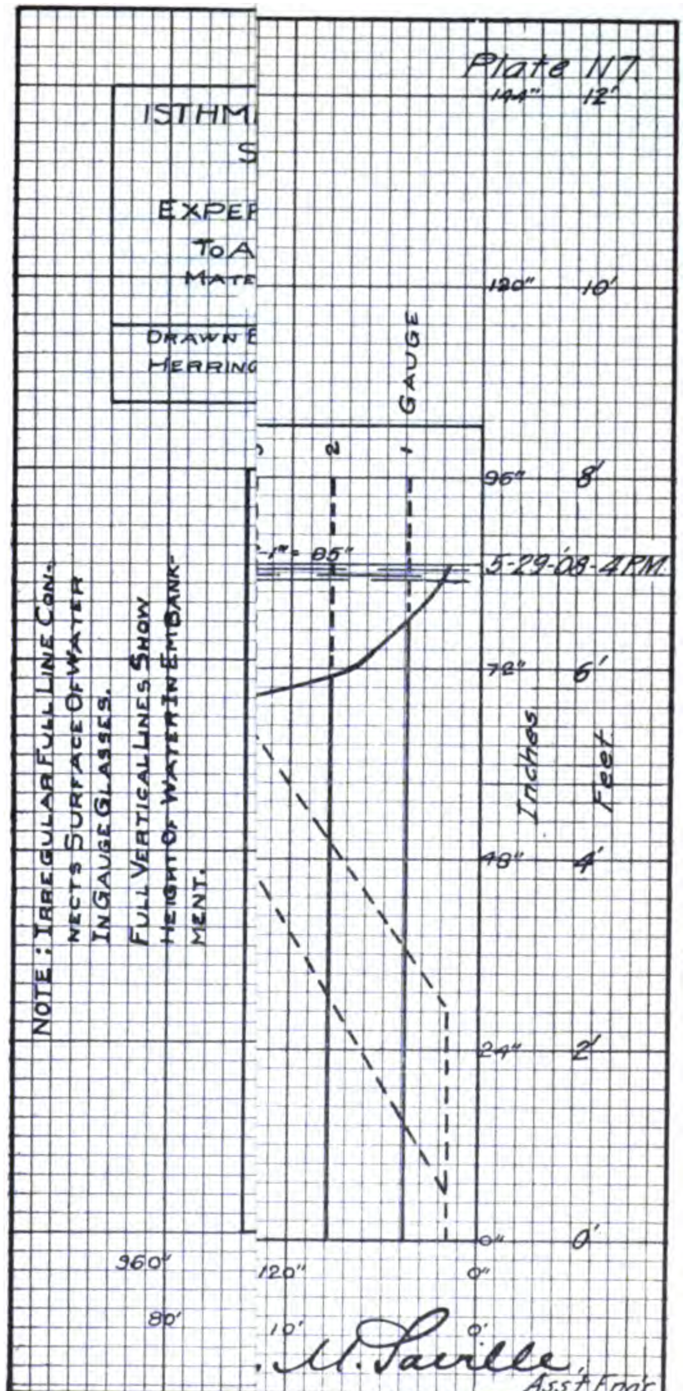


Plate N7
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
GAUGE
2
1
5-29-08-4 P.M.
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches
Feet
960'
120"
0"
80'
10'
0'
M. Saville,
Ass't Engr.

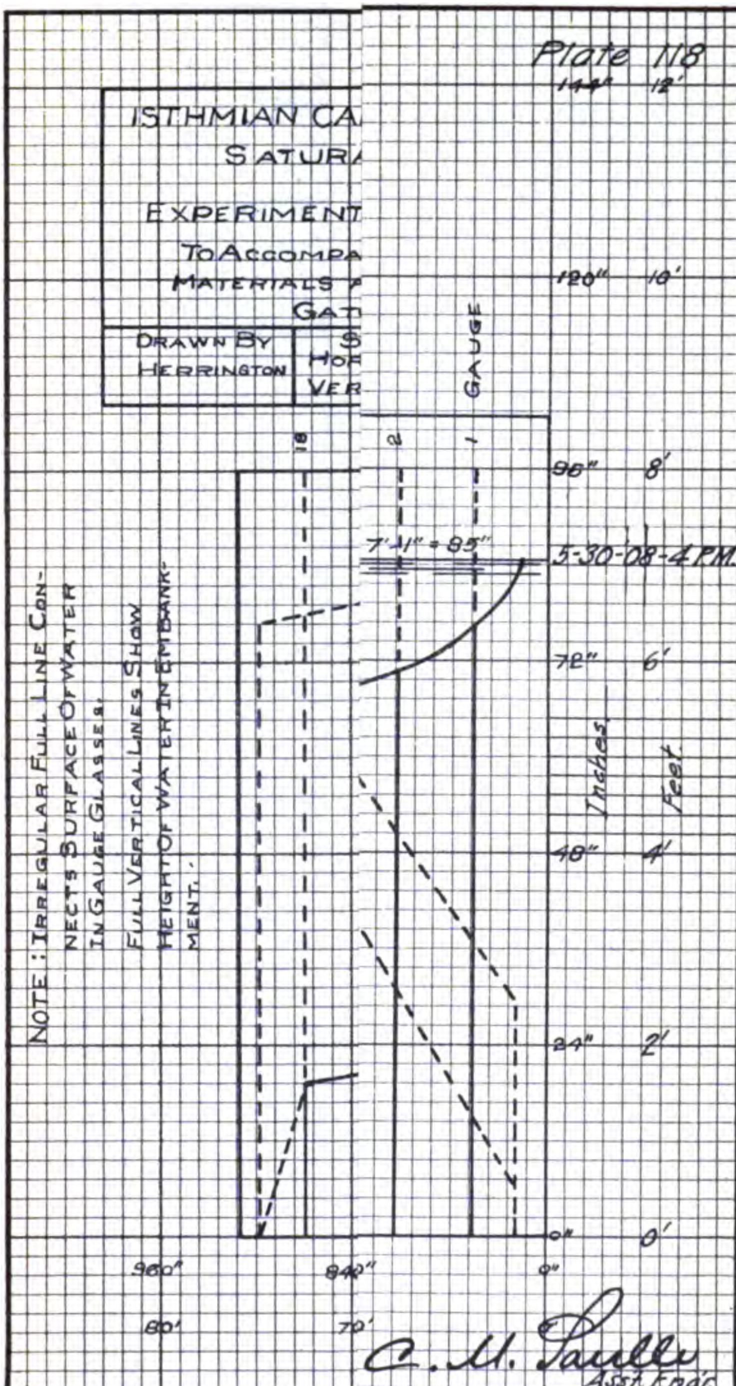


Plate 118
ISTHMIAN CA
SATURA
EXPERIMENT
To Accompa
Materials
Gat
Drawn By
Herrington
Hor
Ver
Gauge
18
2
1
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches
Feet
7'-1" = 85"
5-30-08-4 P.M.
NOTE: Irregular Full Line Connects Surface of Water in Gauge Glasses.
Full Vertical Lines Show Height of Water in Embankment.
960"
840"
0"
80'
70'
C. M. Saville
Asst. Engr.

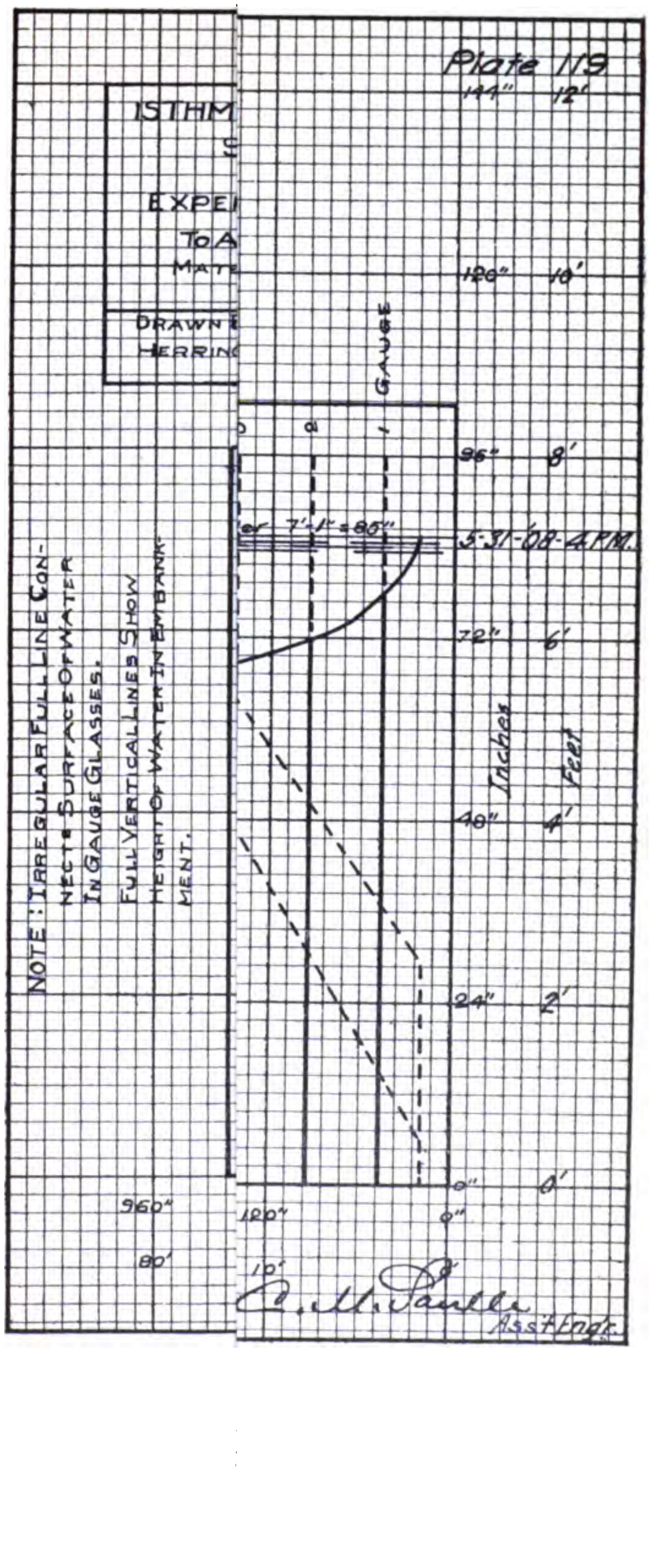
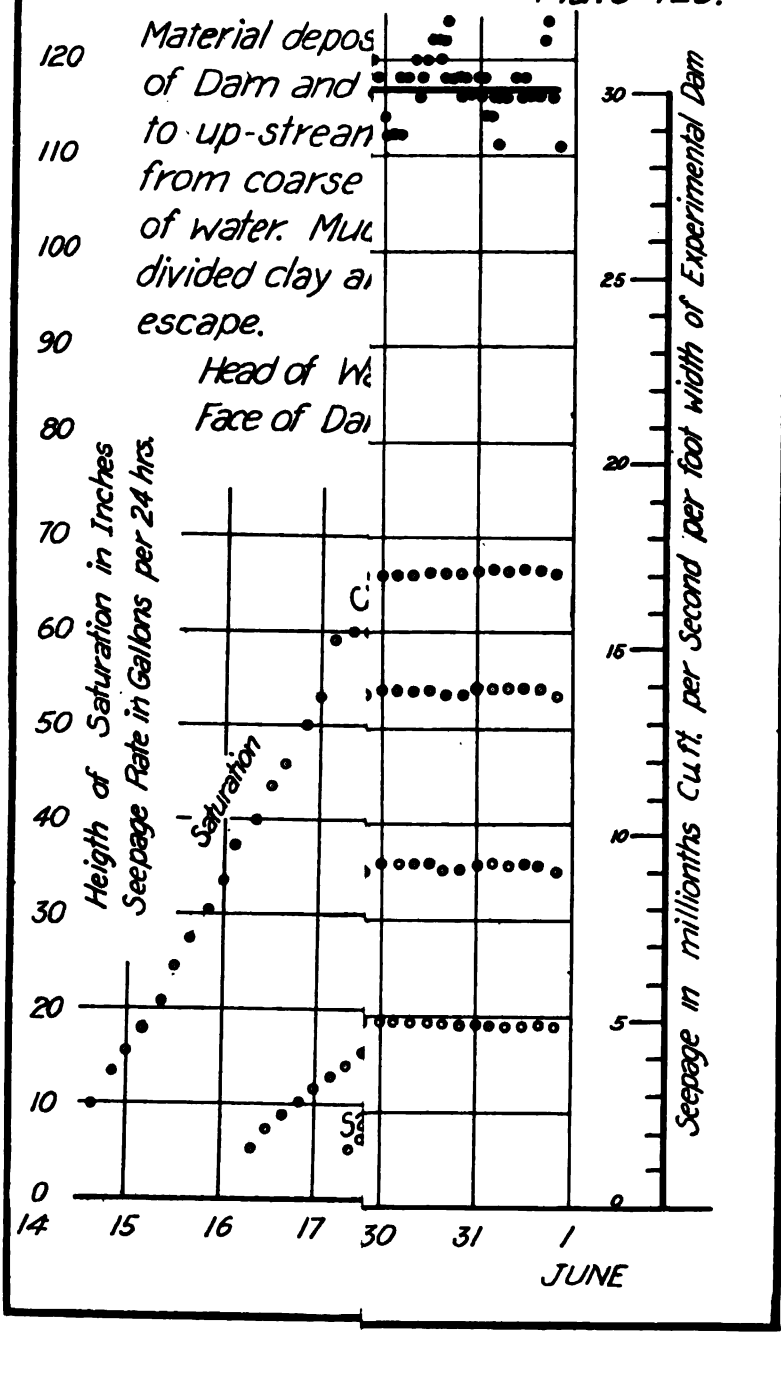


Plate 119
ISTHM
EXPE
To A
MATE
DRAWN
HERRIN
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
GAUGE
7'-1" = 85"
5-31-08-4 P.M.
144" 12'
120" 10'
96" 8'
72" 6'
Inches
Feet
48" 4'
24" 2'
0" 0'
960"
80'
120"
10'
0"
0'
Asst Engr.

DIAGRAM SITAL DAM TYPE I

Plate 120.



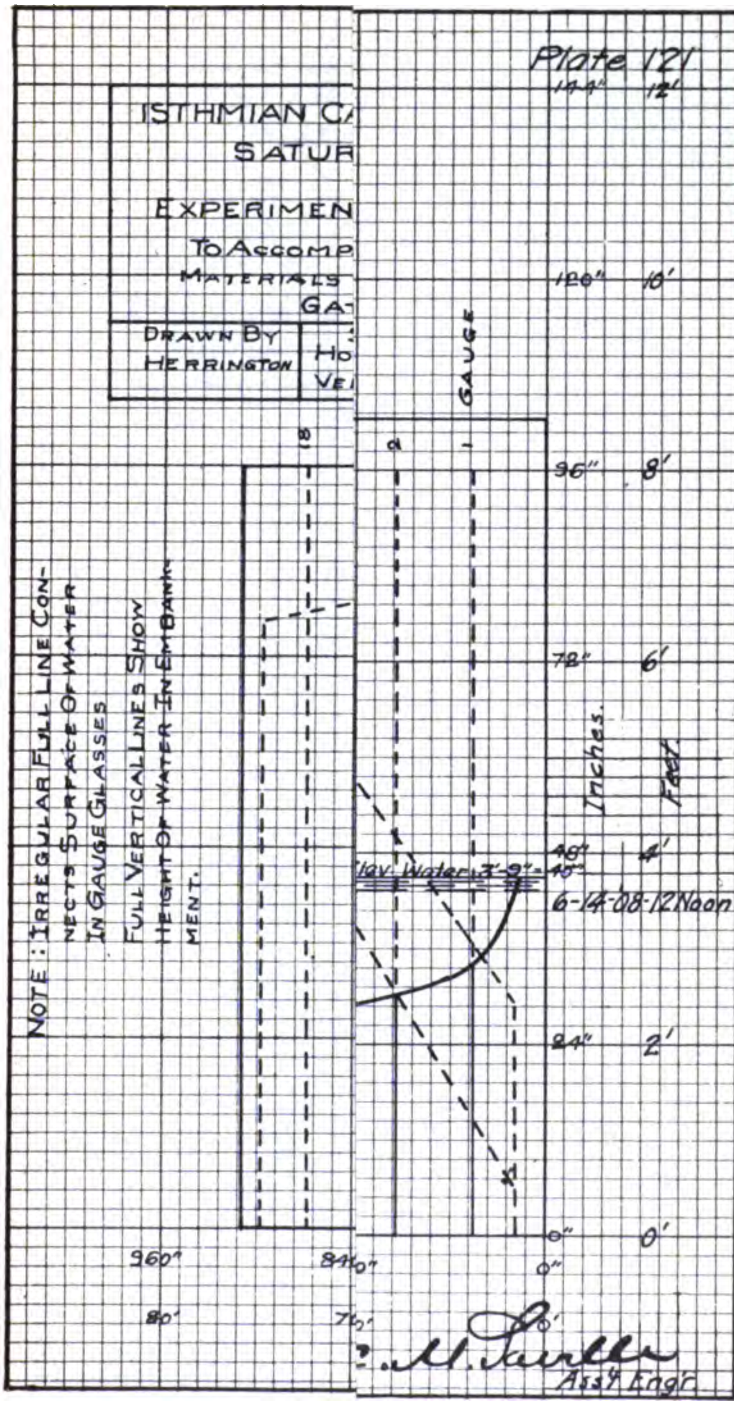


Plate 121
ISTHMIAN C
SATUR
EXPERIMEN
To Accomp
Materials
Ga
Drawn By
Herrington
Ho
Ve
Gauge
18
2
1
Note: Irregular Full Line Connects Surface Of Water In Gauge Glasses
Full Vertical Lines Show Height Of Water In Embankment.
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches.
Feet.
Elev. Water 3'-9"
6-14-08-12 Noon
960"
840"
0"
80'
70'
0'
Ass't Engr.

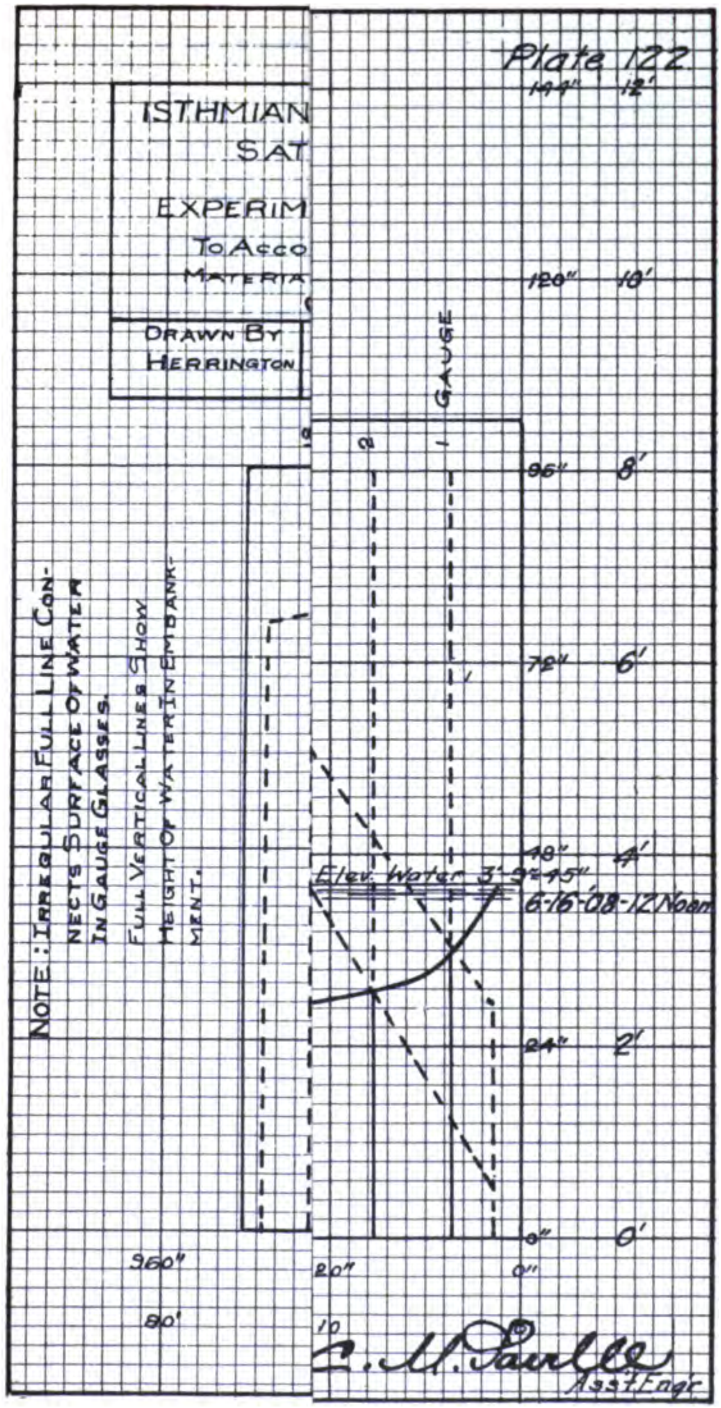


Plate 122
ISTHMIAN
SAT
EXPERIM
To Acco
Materia
Drawn By
Herrington
GAUGE
2
1
144"
12'
120"
10'
96"
8'
72"
6'
48"
4'
24"
2'
0"
0'
Elev. Water 3'-9"
6-16-08-12 Noon
960"
80'
20"
10
0"
Asst. Engr
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.

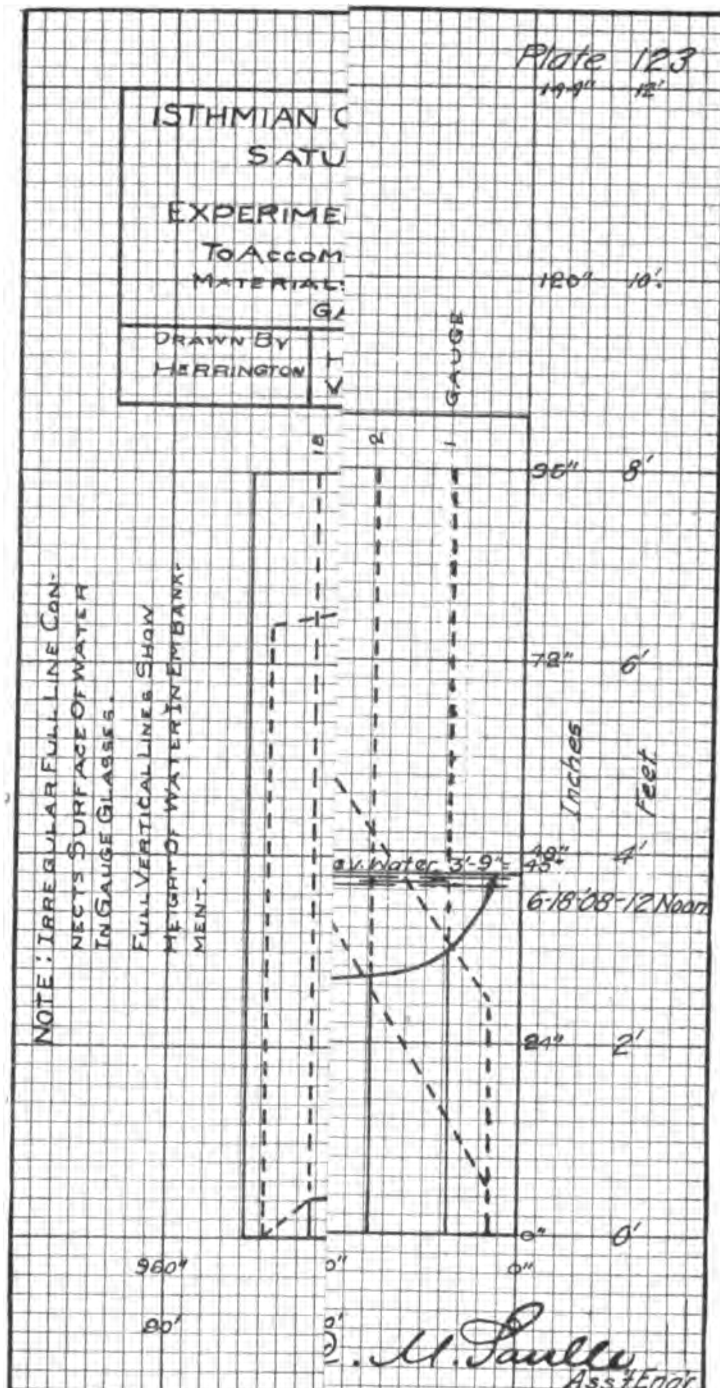


Plate 123
ISTHMIAN C
SATU
EXPERIME
To Accom
Materia
GA
Drawn By
Herrington
GAUGE
NOTE: Irregular Full Line Connects Surface Of Water In Gauge Glasses.
Full Vertical Lines Show Height Of Water In Embankment.
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0" 0'
Inches
Feet
Av. Water 3'-9"
6-18-08-12 Noon
960"
80'
0"
D. M. Paulle
Ass't Engr.

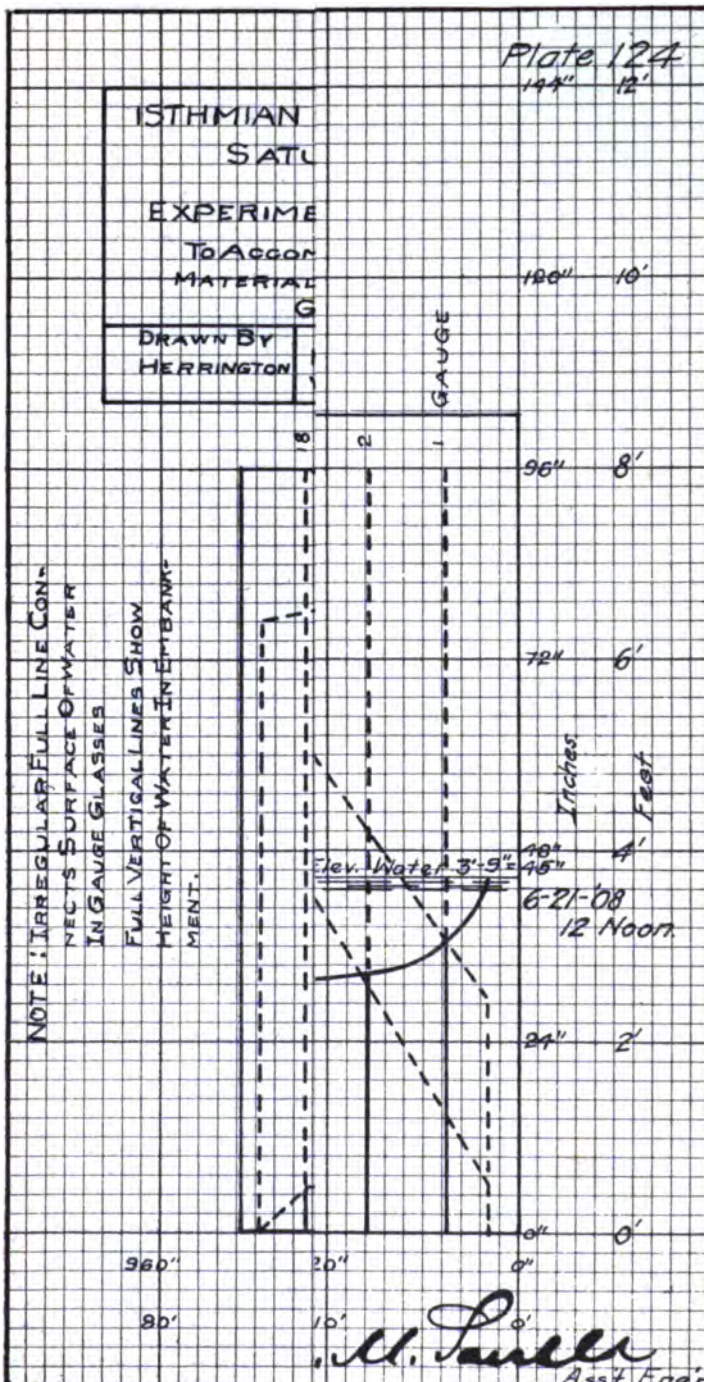


Plate 124
ISTHMIAN
SATU
EXPERIME
To Accor
Material
G
Drawn By
Herrington
Gauge
18
2
1
144" 12'
120" 10'
96" 8'
72" 6'
Inches
Feet
48" 4'
Elev. Water 3'-9" = 45"
6-21-08
12 Noon
24" 2'
0" 0'
960"
20"
0"
80'
10'
0'
Note: Irregular Full Line Connects Surface of Water in Gauge Glasses
Full Vertical Lines Show Height of Water in Embankment.
Ass't Eng'r

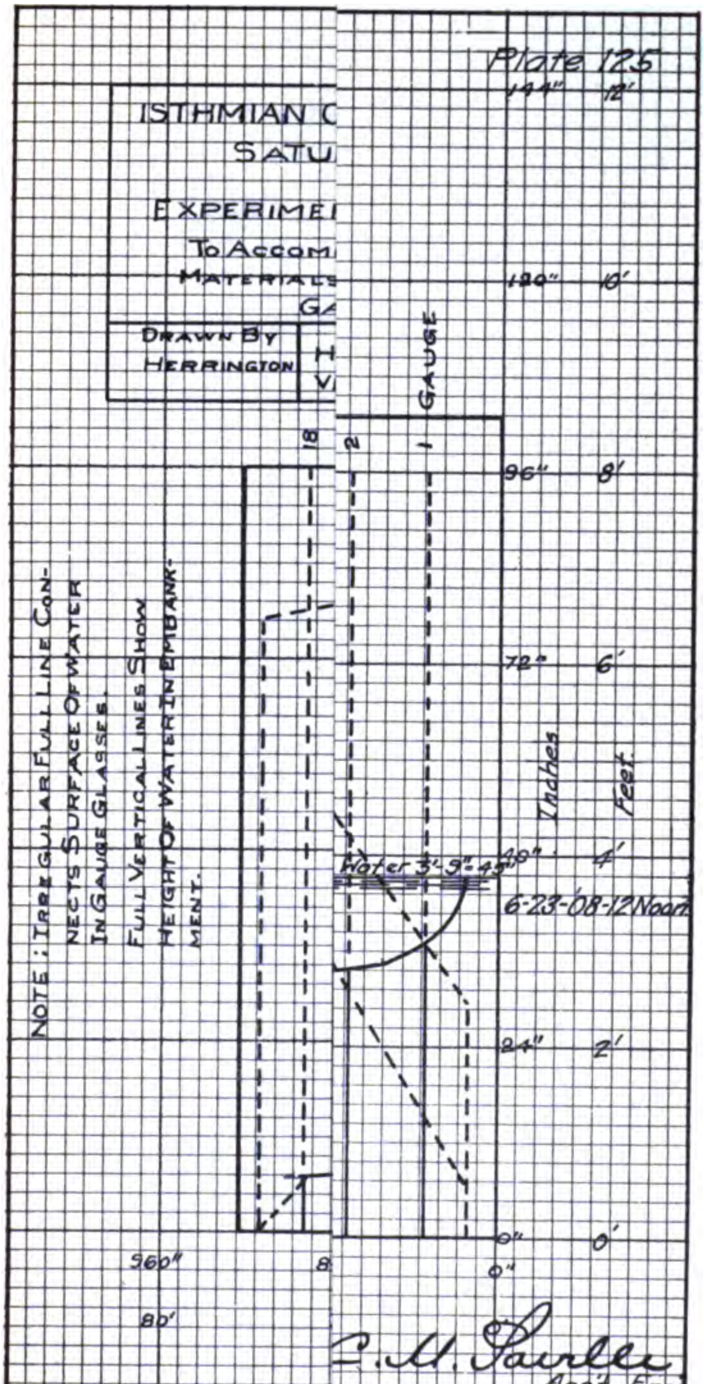


Plate 125
ISTHMIAN C
SATU
EXPERIME
To Accom
Materials
GA
Drawn By
Herrington
GAUGE
18
2
1
144" 12'
120" 10'
96" 8'
72" 6'
Inches
Feet
48" 4'
Water 3' 9" 45
6-23-08-12 Noon
24" 2'
0" 0'
0"
560"
80'
Asst Engr
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES.
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.

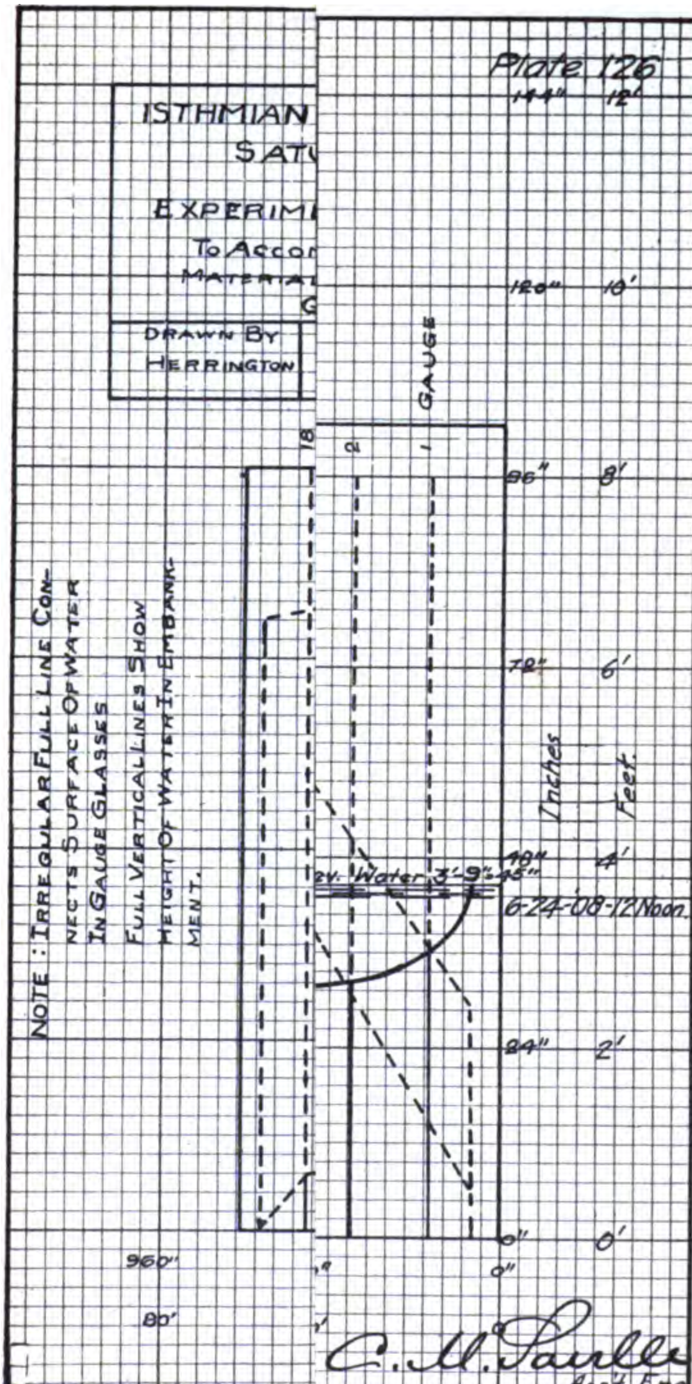


Plate 126
144" 12'
ISTHMIAN
SAT
EXPERIM
To Accor
DRAWN BY
HERRINGTON
120" 10'
GAUGE
18
2
1
96" 8'
72" 6'
Inches
Feet
48" 4'
6-24-08-12 Noon.
24" 2'
0" 0'
960'
0"
80'
NOTE: IRREGULAR FULL LINE CONNECTS SURFACE OF WATER IN GAUGE GLASSES
FULL VERTICAL LINES SHOW HEIGHT OF WATER IN EMBANKMENT.
Asst Eng

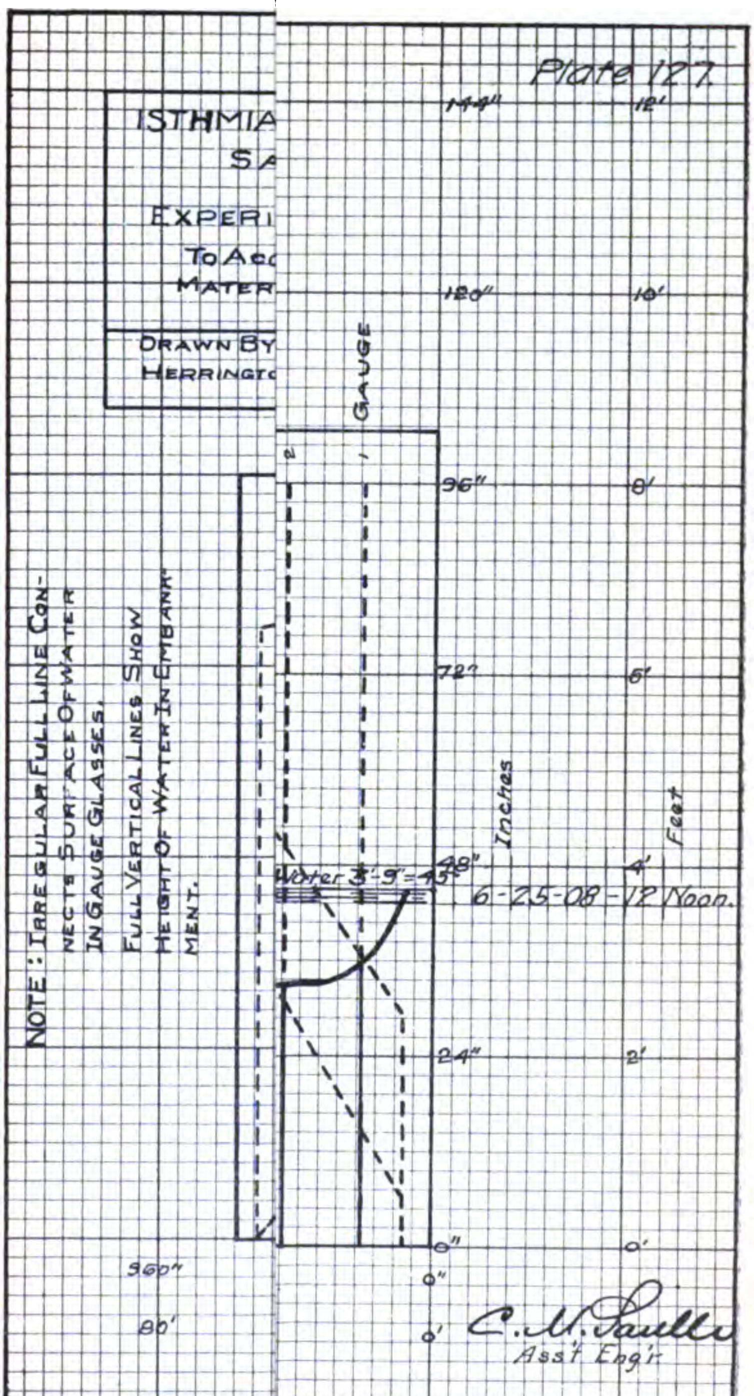


Plate 127
ISTHMIA
SA
EXPERI
To Acc
Mater
Drawn By
Herringto
144"
12'
120"
10'
GAUGE
2
1
96"
8'
72"
6'
Inches
Feet
48"
4'
Water 3'-9"=45"
6-25-08-12 Noon.
24"
2'
0"
0'
360"
30'
Asst Eng'r
NOTE: Irregular Full Line Connects Surface Of Water In Gauge Glasses.
Full Vertical Lines Show Height Of Water In Embankment.

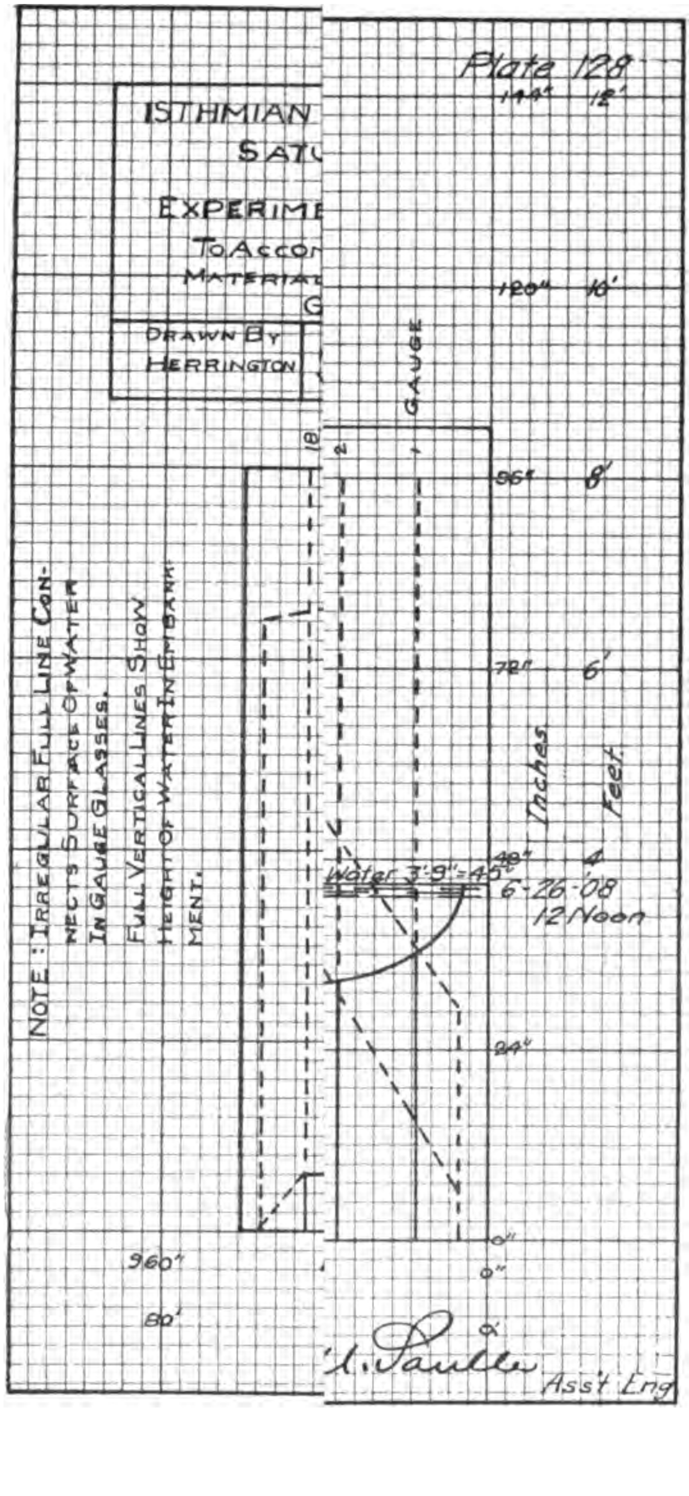


Plate 128
ISTHMIAN
SAT
EXPERIME
To Accor
Materia
G
Drawn By
Herrington
Gauge
144" 12'
120" 10'
96" 8'
72" 6'
48" 4
24"
0"
0'
Inches
Feet
Water 3'9"=45"
6-26-08
12 Noon
Note: Irregular Full Line Connects Surface of Water In Gauge Glasses.
Full Vertical Lines Show Height of Water In Embankment.
960"
80'
Ass't Eng

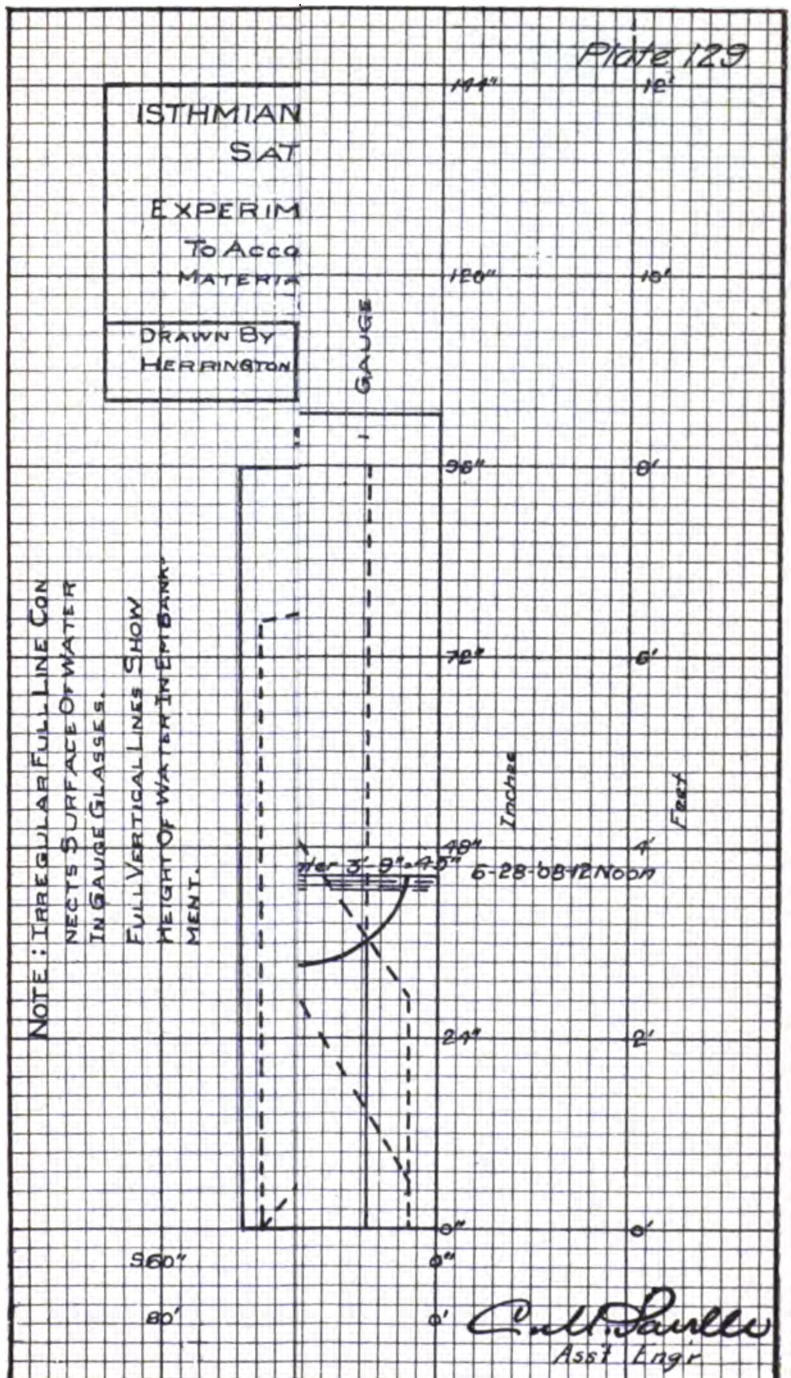


Plate 129
ISTHMIAN
SAT
EXPERIM
To Acco
Materia
Drawn By
Herrington
Gauge
144"
12'
120"
10'
96"
8'
72"
6'
48"
4'
24"
2'
0"
0'
Inches
Feet
Note: Irregular Full Line Connects Surface of Water in Gauge Glasses.
Full Vertical Lines Show Height of Water in Embankment.
6-28-08 12 Noon
560"
0"
80'
0'
Asst Engr

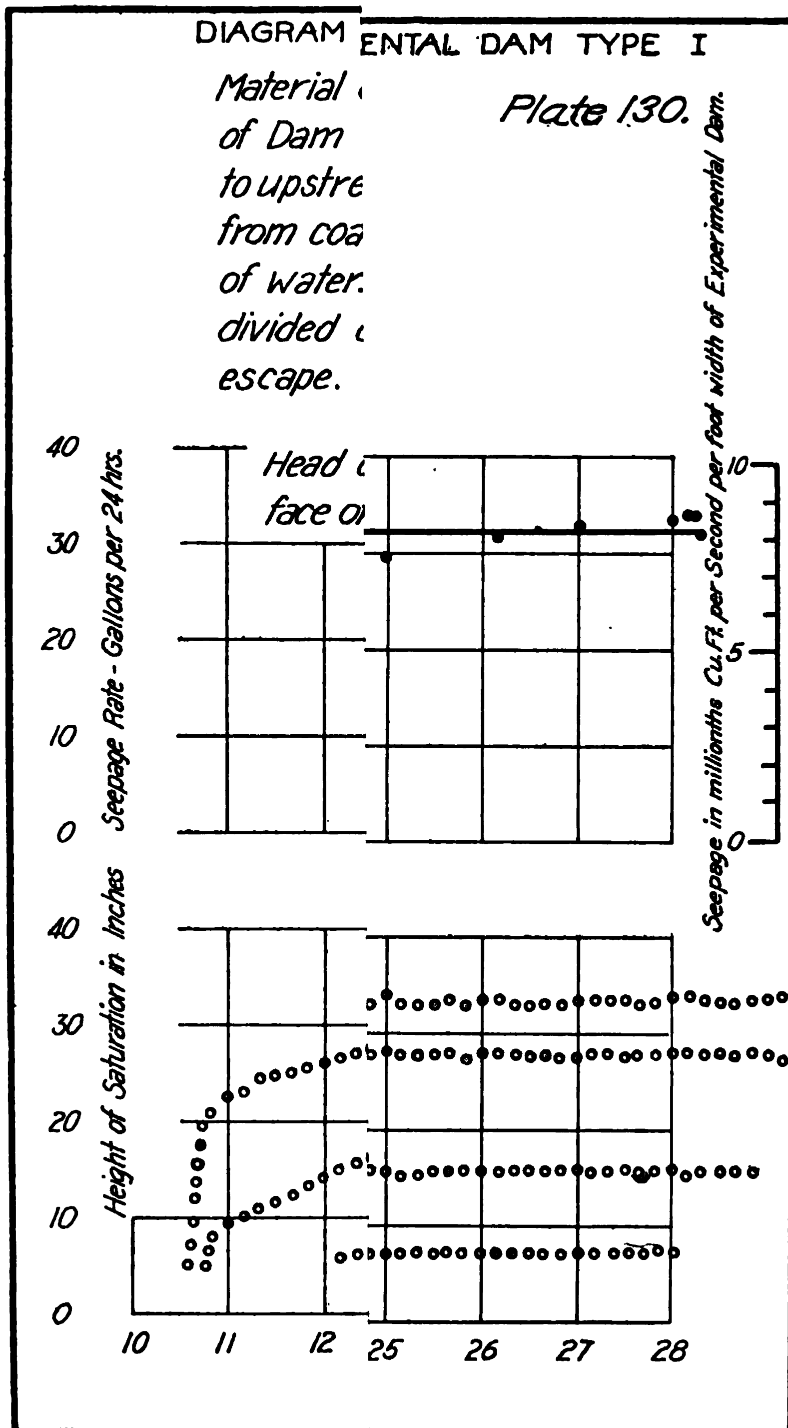


DIAGRAM ENTAL DAM TYPE I
Material
of Dam
to upstre
from coa
of water.
divided
escape.
Plate 130.
Head
face o
Seepage Rate - Gallons per 24 hrs.
Seepage in millionths Cu. Ft. per Second per foot width of Experimental Dam.
Height of Saturation in Inches
40
30
20
10
0
10
5
0
40
30
20
10
0
10
11
12
25
26
27
28

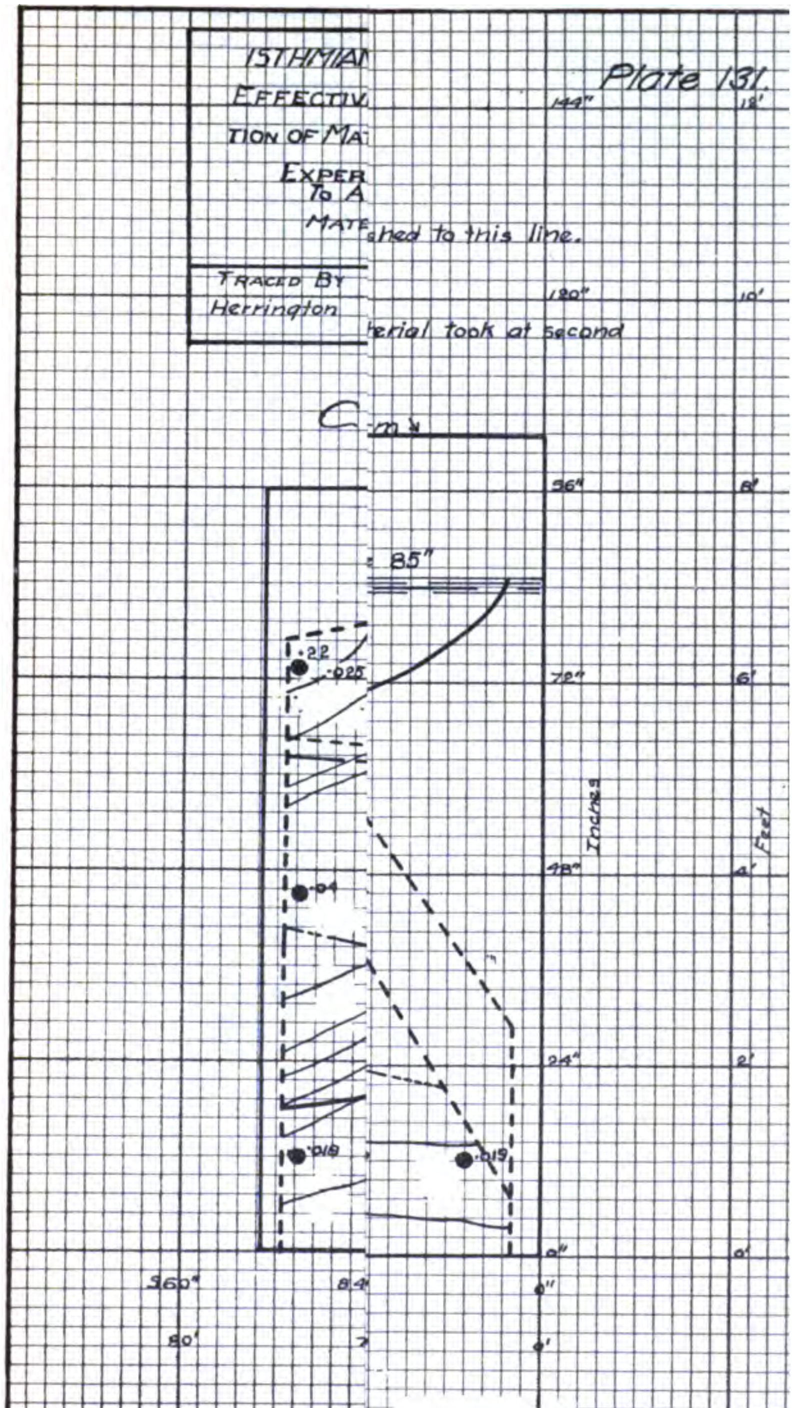
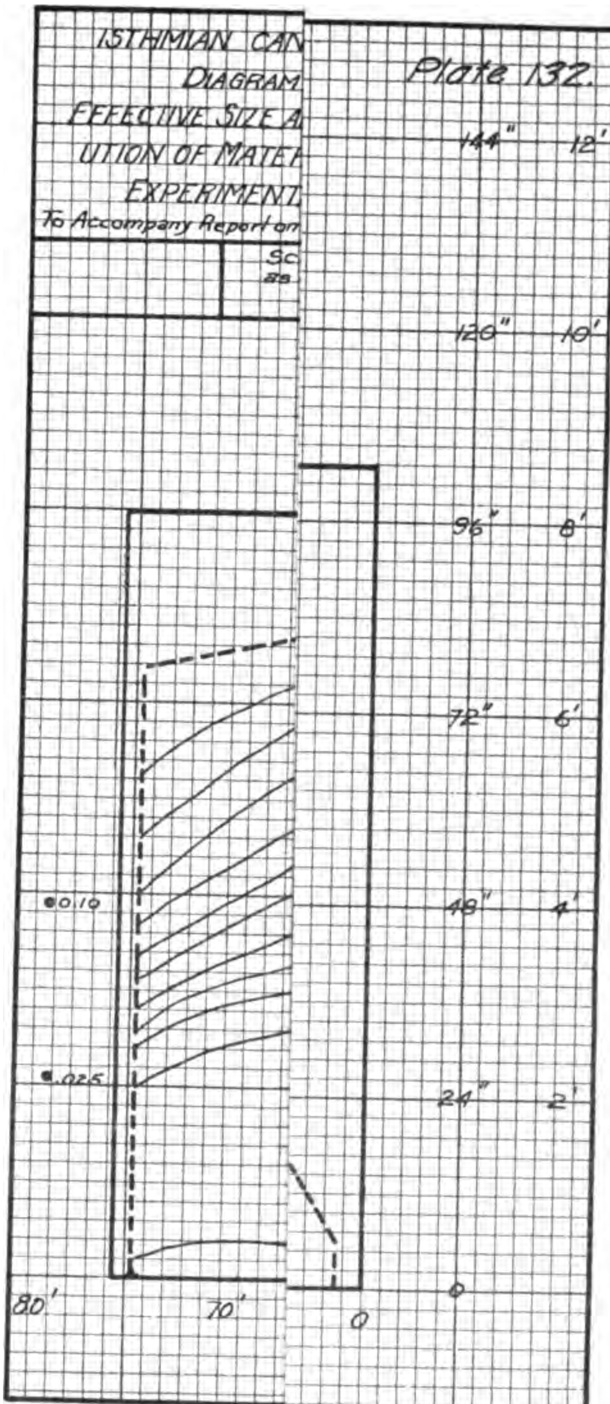
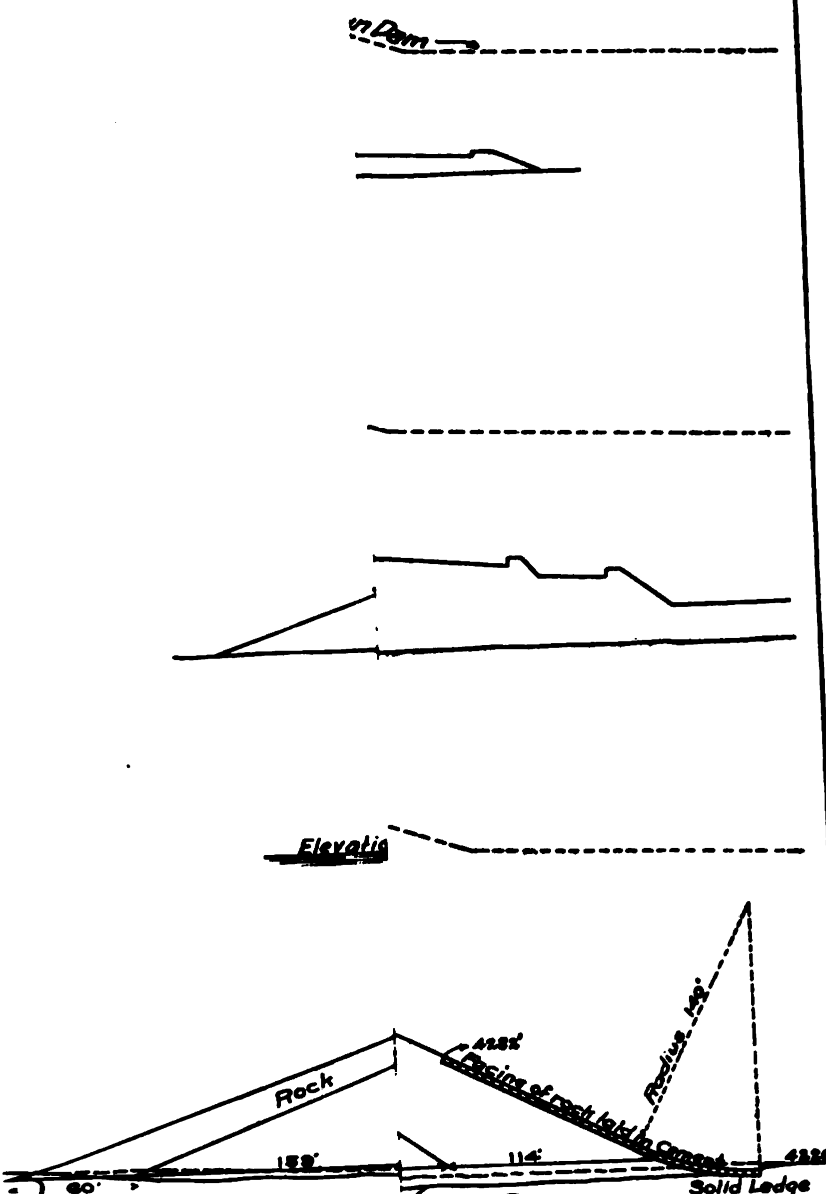


Plate 131.
ISTHMIAN
EFFECTIV
TION OF MA
EXPER
To A
MATE
shed to this line.
TRACED BY
Herrington
terial took at second
85"
144"
12'
120"
10'
96"
8'
72"
6'
48"
4'
24"
2'
0"
0'
Inches
Feet
.22
.025
.04
.018
.019
360"
80'



ISTHMIAN CAN
DIAGRAM
EFFECTIVE SIZE A
UTION OF MATEF
EXPERIMENT
To Accompany Report on
Plate 132.
144" 12'
120" 10'
96" 8'
72" 6'
48" 4'
24" 2'
0
0.010
.025
80'
70'
0

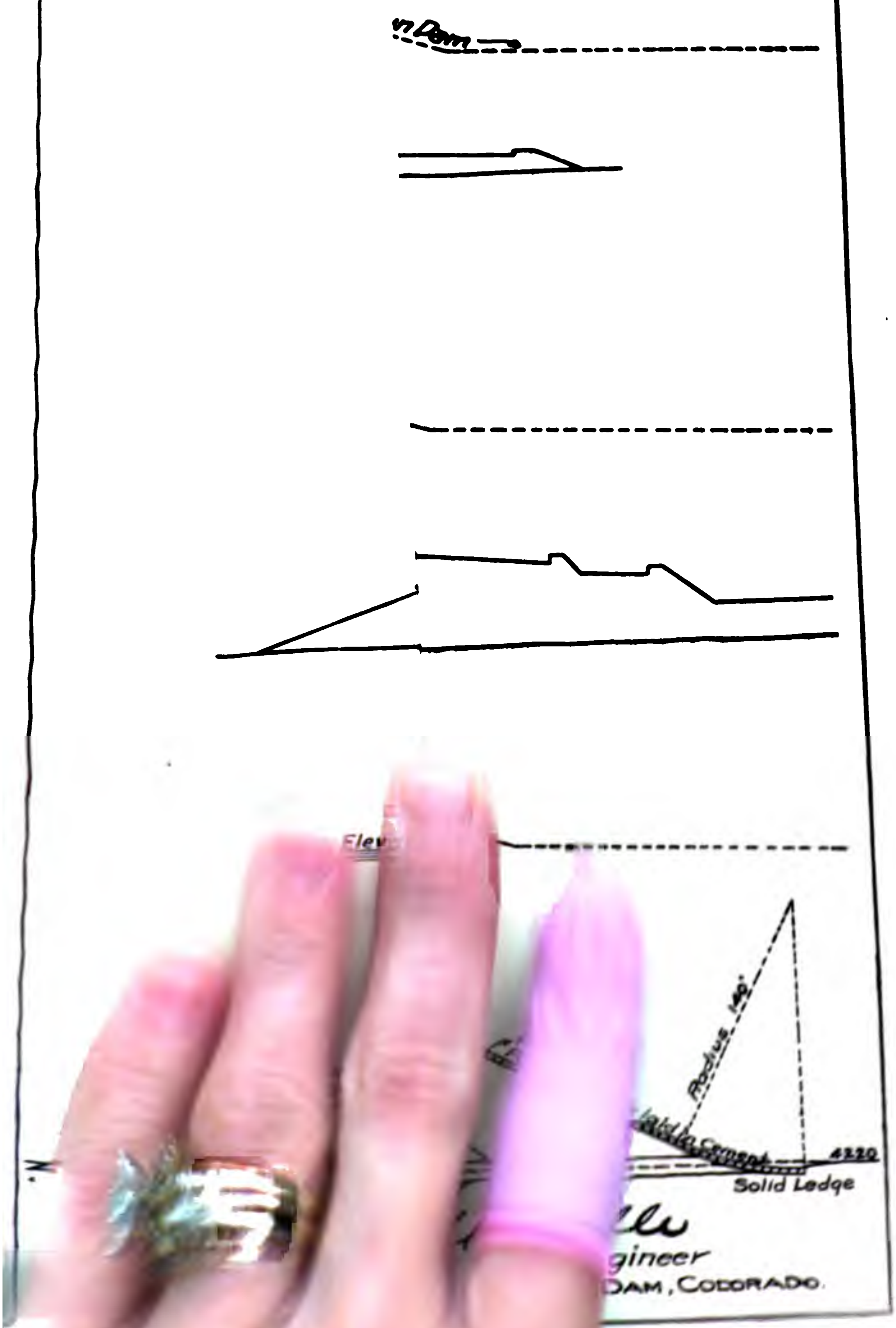
Plate 133.



Ass't Engineer

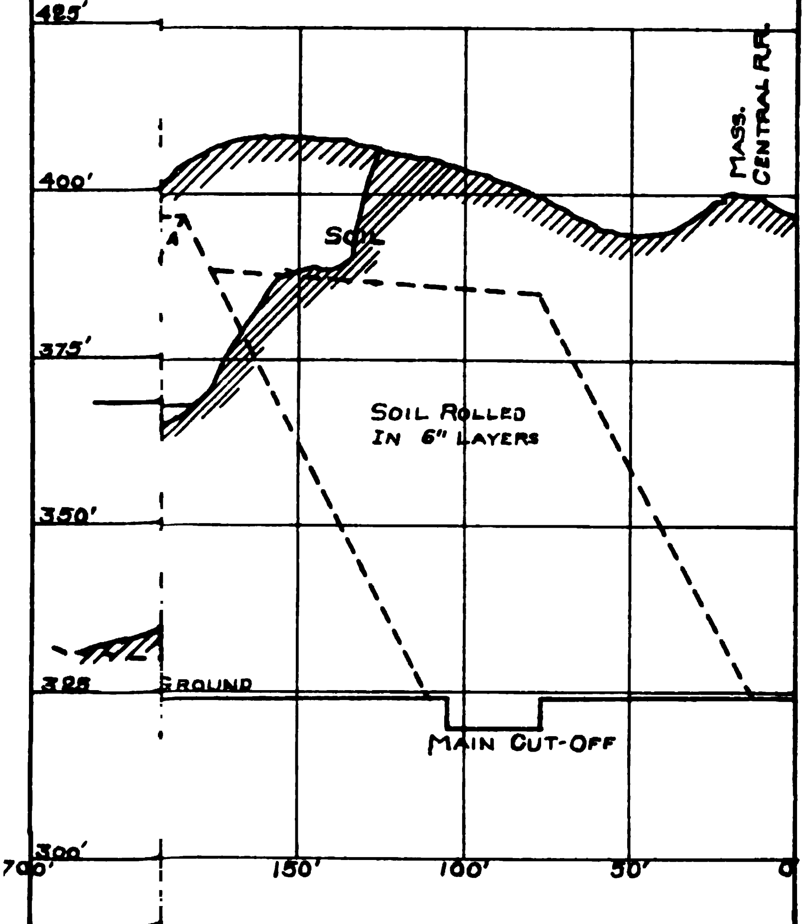
Cross Sectio Reservoir Dam, Colorado.

Plate 133.



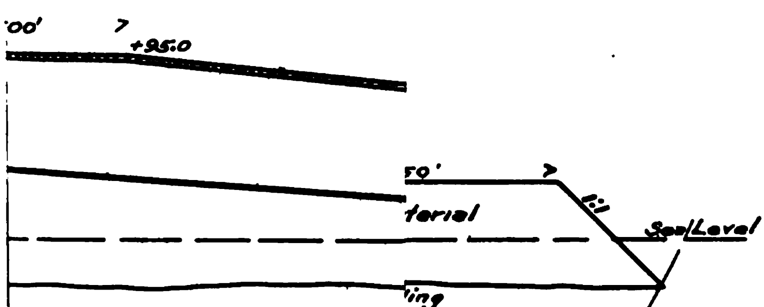
Radius 140'
Laid in Cement
4320
Solid Ledge
gineer
Dam, Colorado

Plate 134



425'
400'
375'
350'
325
300'
700'
150'
100'
50'
0
Mass. Central R.R.
Soil
Soil Rolled In 6" Layers
Ground
Main Cut-Off

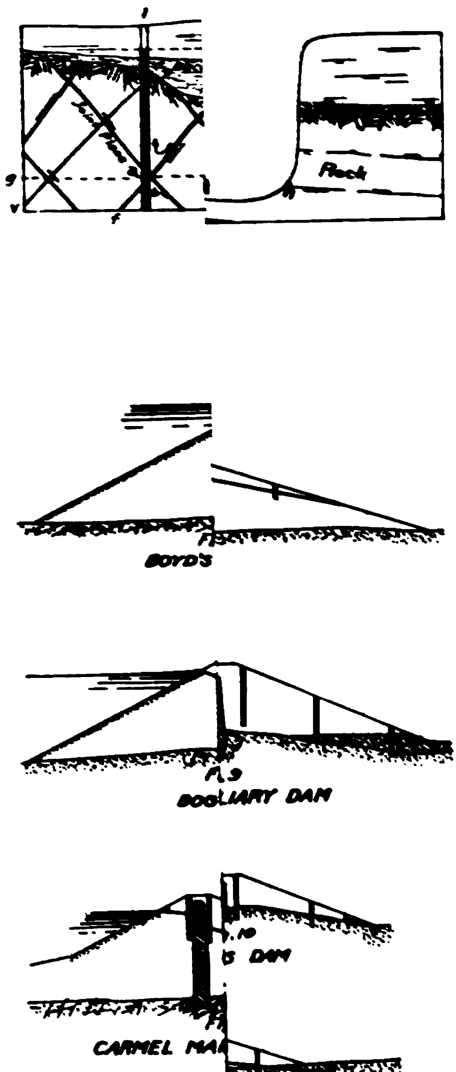
Plate 135.



L COMMISSION
NE OF
GATUN DAM
SECTION
ry Report
d Foundations,
Dam
1:1200.

C. M. Saville
Ass't Eng'r

Plate 136.



Saville
Ass't Eng'r

Plate 137.

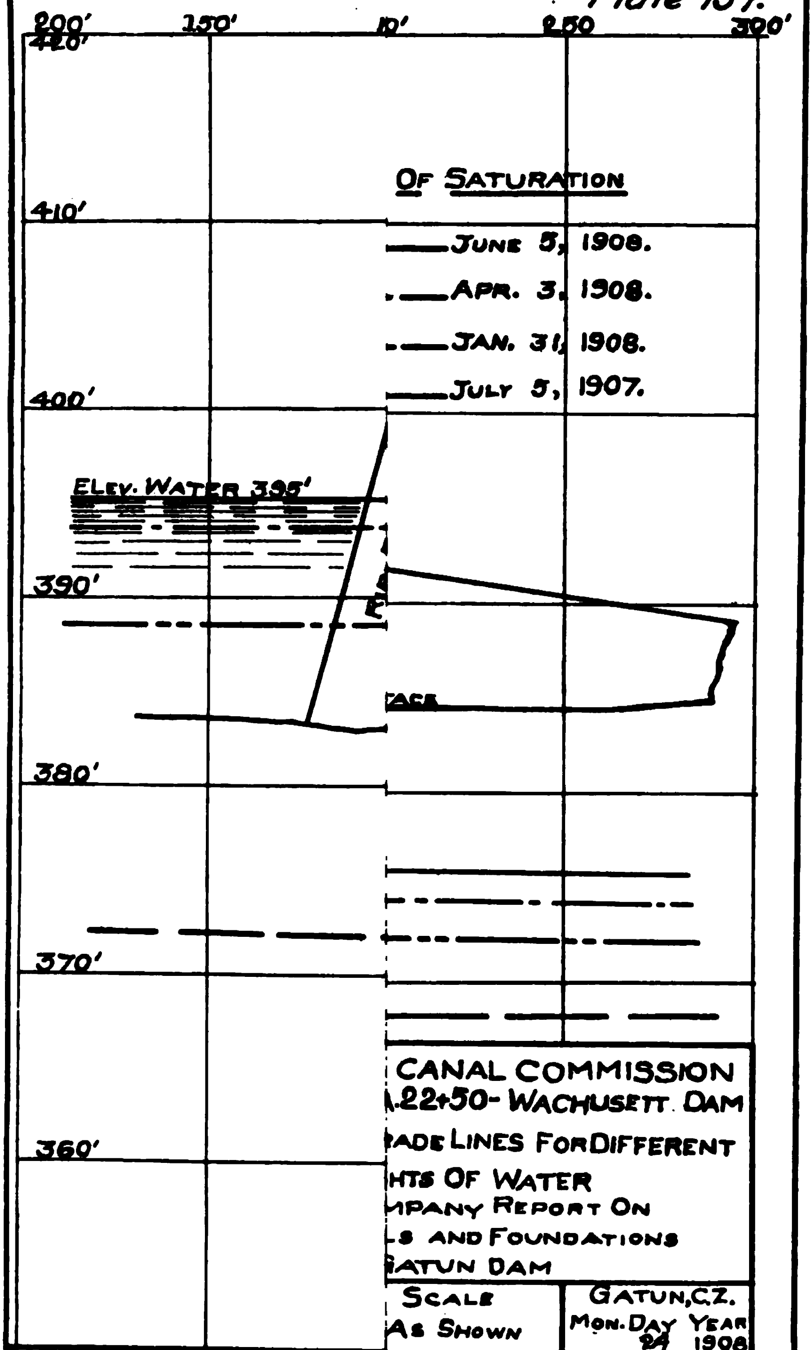
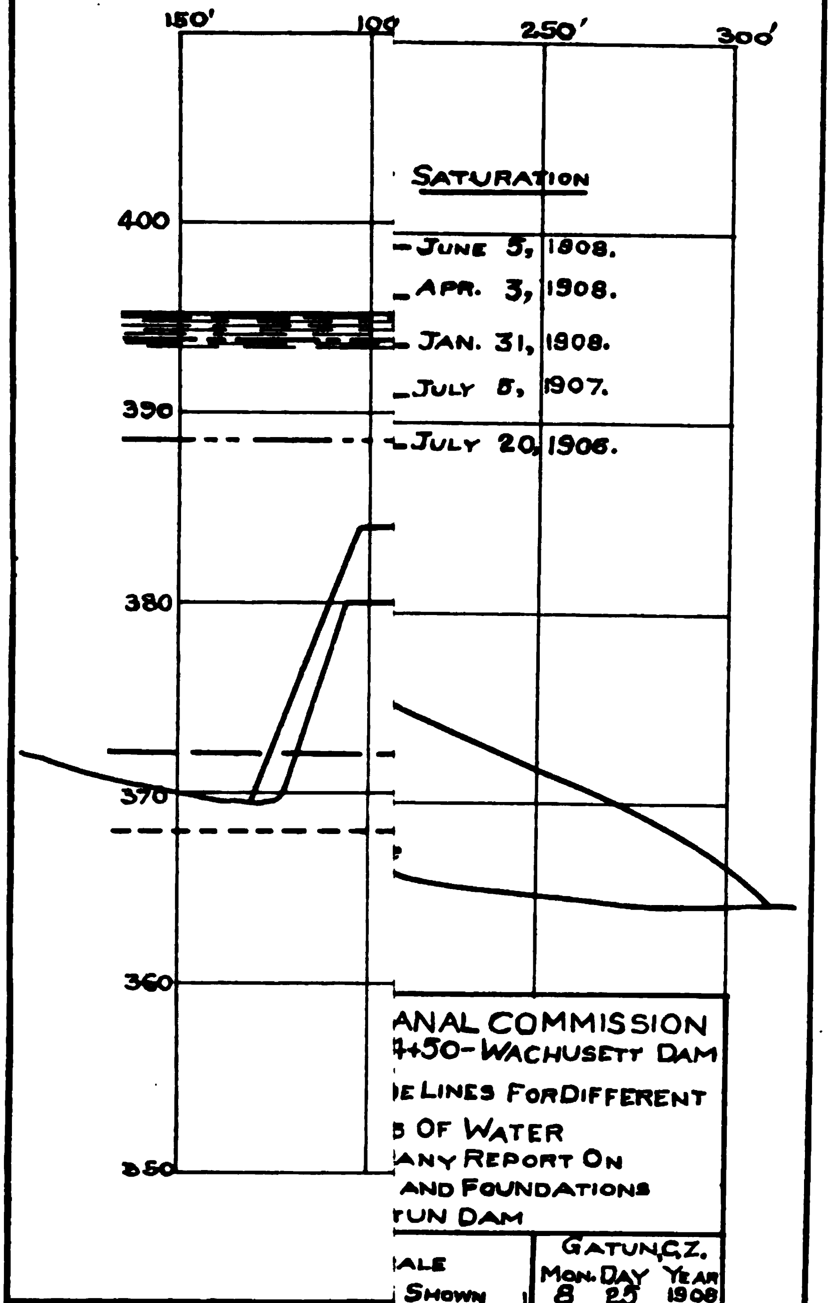
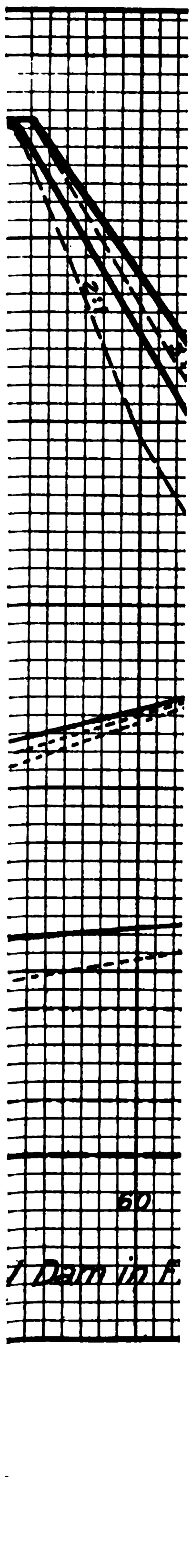

200'
150'
250
300'
420'
410'
400'
390'
380'
370'
360'
Of Saturation
June 5, 1908.
Apr. 3, 1908.
Jan. 31, 1908.
July 5, 1907.
Elev. Water 395'
CANAL COMMISSION
.22+50- Wachusett Dam
ade Lines For Different
hts Of Water
mpany Report On
s And Foundations
Gatun Dam
Scale
As Shown
Gatun, C.Z.
Mon. Day Year
24 1908

Plate 138.



150'
100'
250'
300'
Saturation
400
390
380
370
360
350
—June 5, 1908.
—Apr. 3, 1908.
— Jan. 31, 1908.
—July 5, 1907.
—July 20, 1906.
ANAL COMMISSION
4+50-Wachusett Dam
IE Lines For Different
S Of Water
ANY Report On
And Foundations
TUN Dam
ALE
Shown
Gatun, C.Z.
Mon. Day Year
8 25 1908


60
Dam in F

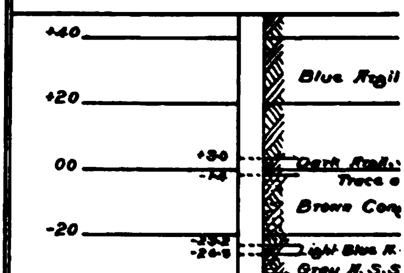
GA

BORINGS

FO

Sect

ELEVATION OF GROUND +47.0



Elev. of Bottom: -33.5 August,

ISTHMIAN CANAL COMMISSIO

DIAGRAM
To Accompany Report on
Materials and Foundations

	Gatun C.Z. 8/26 '08	

Elevations are referred to mean low water

Box.................... Tray.... ... .

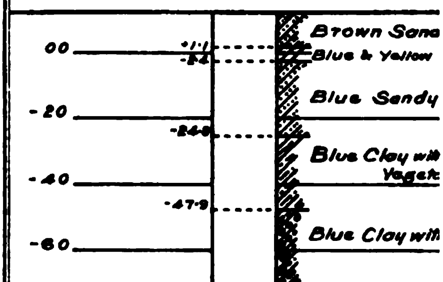
GAT

BORINGS

FOU

Sectior

ELEVATION OF GROUND ±12·2



Elev. of Bottom : -71·9 August, 22,

ISTHMIAN CANAL COMMISSION

DIAGRAM
To Accompany Report on
Materials and Foundations

	Gatun C.Z. 4/26 '08	

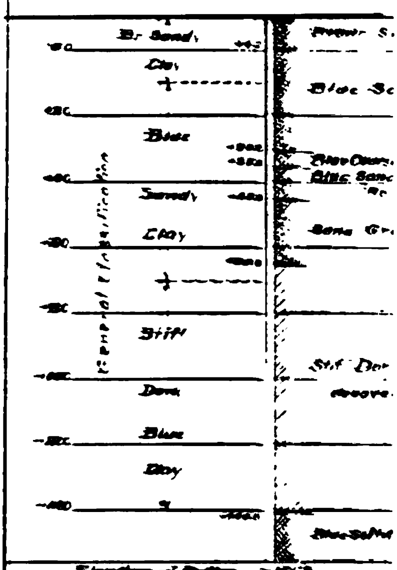
Elevations are referred to mean low water at

Box........ Tray........

BORING

FO

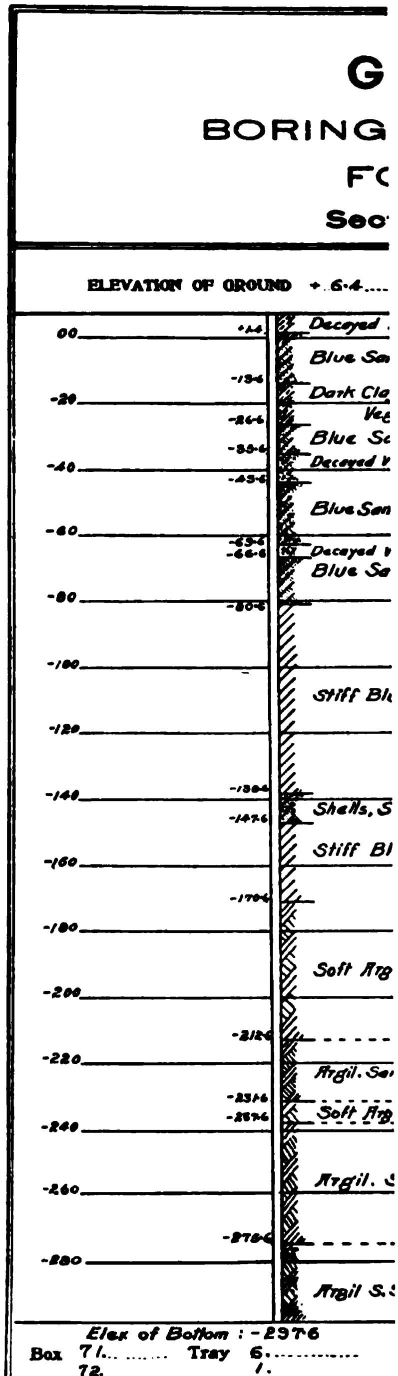
ELEVATION OF GROUND +9.2



Elevations are referred to mean low wat

Wash Samples unless otherwise noted

Box.............. Tray ...



G
BORING
FC
Sec
ELEVATION OF GROUND + 6·4
00
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
+1·4
-13·6
-26·6
-35·6
-45·6
-65·6
-66·6
-80·6
-138·6
-147·6
-170·6
-212·6
-231·6
-237·6
-278·6
Decayed
Blue Sa
Dark Cla
Veg
Blue Sa
Decayed V
Blue San
Decayed V
Blue Sa
Stiff Bl
Shells, S
Stiff Bl
Soft Arg
Argil. Sa
Soft Arg
Argil. S
Argil S. S
Elev of Bottom : -297·6
Box 71. Tray 6.
72. 1.

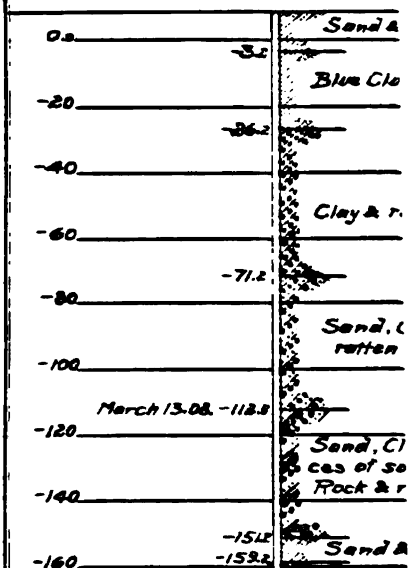
G.

BORINGS

FC

Sect

ELEVATION OF GROUND + B. 8. ....



Elevation of Bottom -16

Elevations are referred to mean low water

Wash Samples unless otherwise noted

Box 63.......... **Tray** 3...........

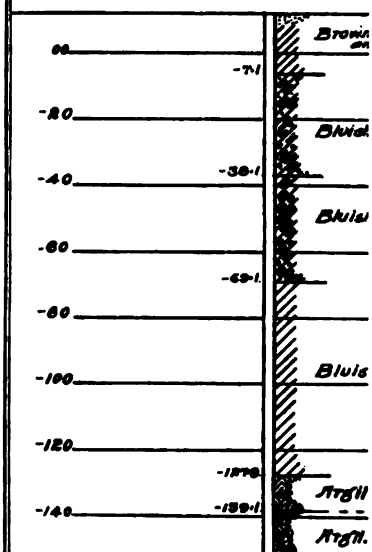
C

BORINC

F

Se

ELEVATION OF GROUND + 10·9..



Elevation of Bottom -154·6.

Elevations are referred to mean low w

Wash Samples unless otherwise noted

Box 6a........Tray 5..........

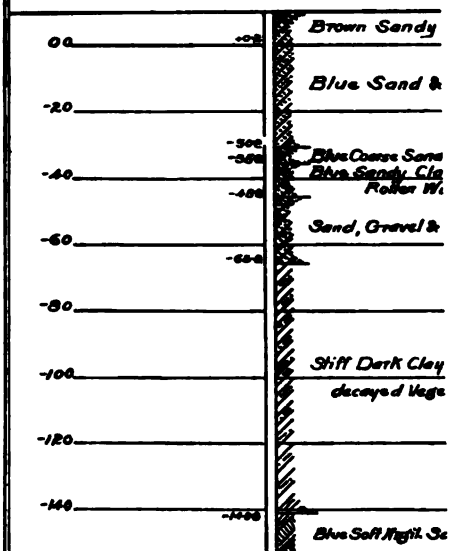
GAT

BORINGS

FOU

Sectior

ELEVATION OF GROUND _ + 9·2 ....



Elevation of Bottom : -155·0.

Elevations are referred to mean low water at (

Wash Samples unless otherwise noted

Box.................. Tray..................

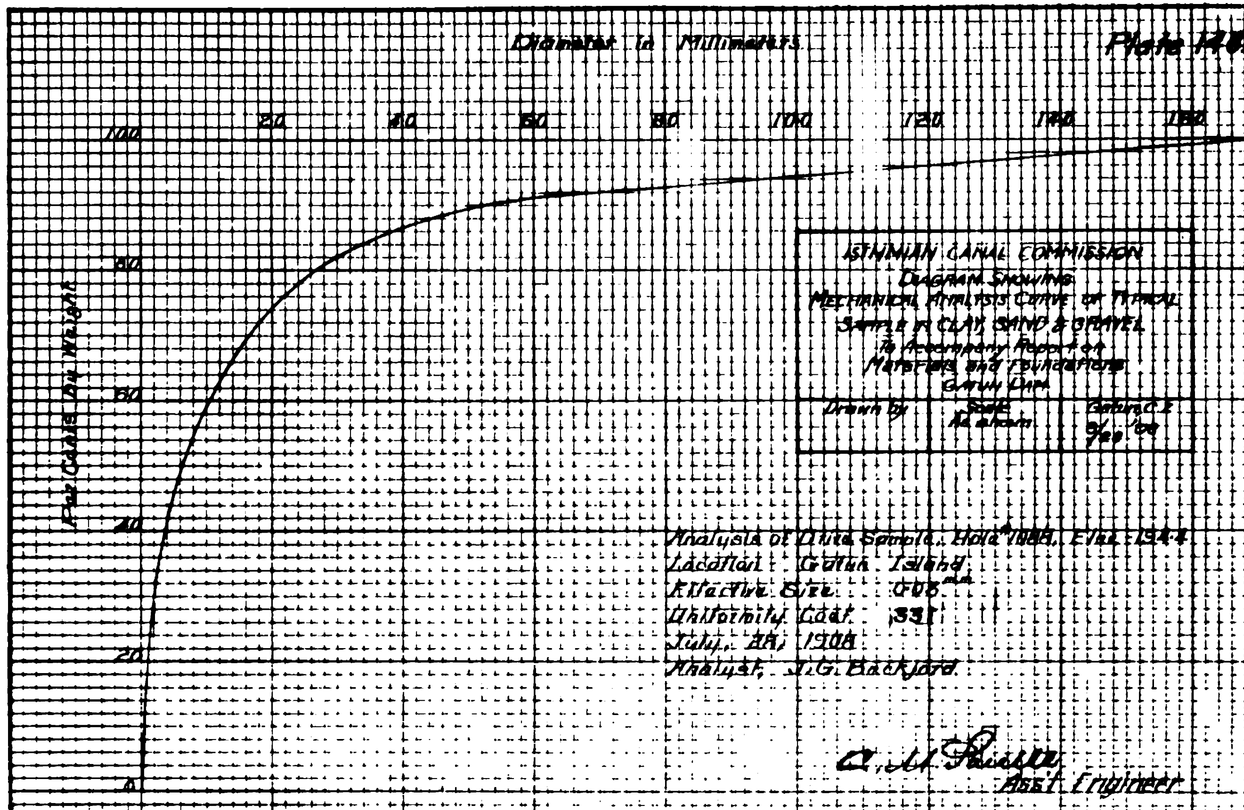


Plate 1
Diameter in Millimeters
0
20
40
60
80
100
120
140
160
Per Cents by Weight
0
20
40
60
80
100
ISTHMIAN CANAL COMMISSION
Diagram Showing
Mechanical Analysis Curve of Typical
Sample of Clay, Sand & Gravel
To Accompany Report on
Materials and Foundations
Gatun Dam
Drawn by
Scale
As shown
Gatun C.Z.
9/29 '08
Analysis of Dune Sample, Hole #1088, Elev. -194.4
Location: Gatun Island
Effective Size 0·08 mm
Uniformity Coef. 33
July 28, 1908
Analyst, J. G. Backjord
Ass't Engineer

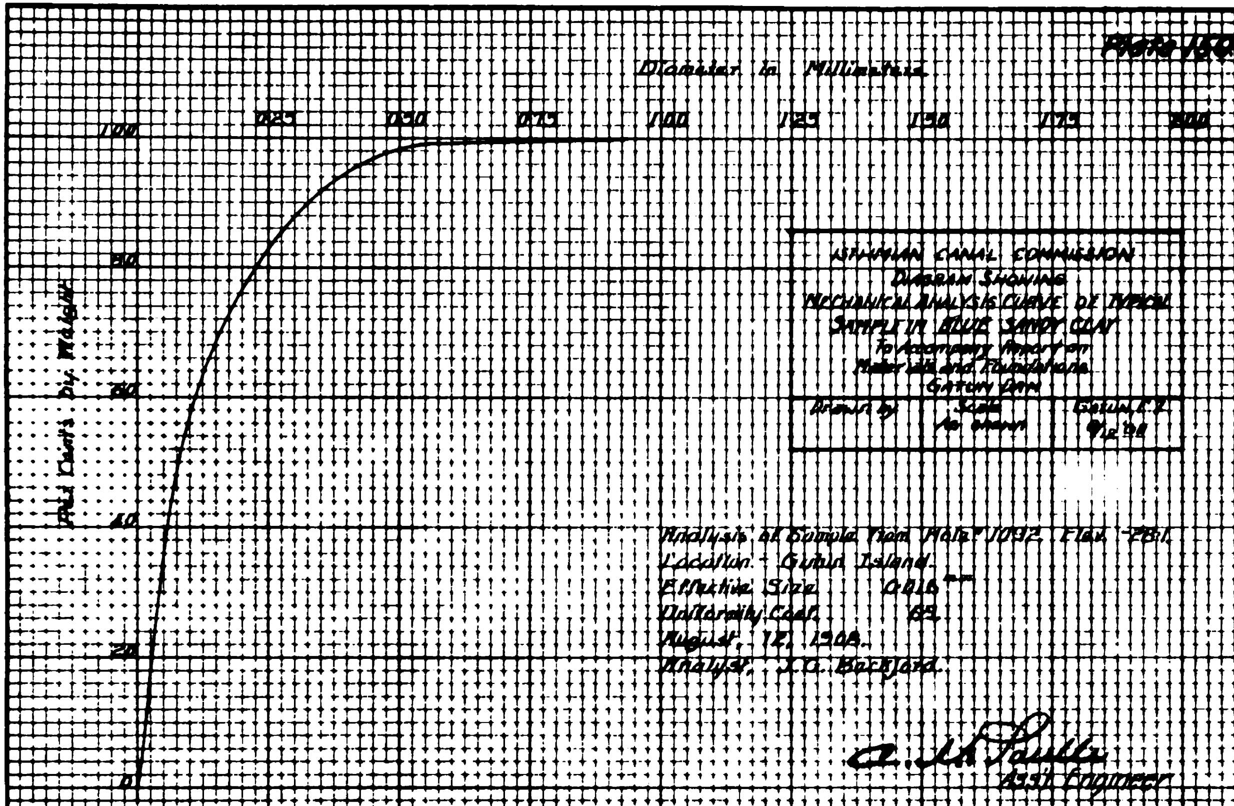


Plate 150.
Diameter in Millimeters
100
.025
.050
.075
.100
.125
.150
.175
.200
80
60
40
20
0
Per Cent's by Weight
ISTHMIAN CANAL COMMISSION
DIAGRAM SHOWING
MECHANICAL ANALYSIS CURVE OF TYPICAL
SAMPLE IN BLUE SANDY CLAY
To Accompany Report on
Materials and Foundations
GATUN DAM
Drawn by
Scale
As shown
Analysis of Sample from Hole No. 1092. Elev. -78.1.
Location - Gatun Island.
Effective Size 0.016 mm
Uniformity Coef. 65.
August, 12, 1908.
Analyst, J.G. Backjord.
Asst. Engineer

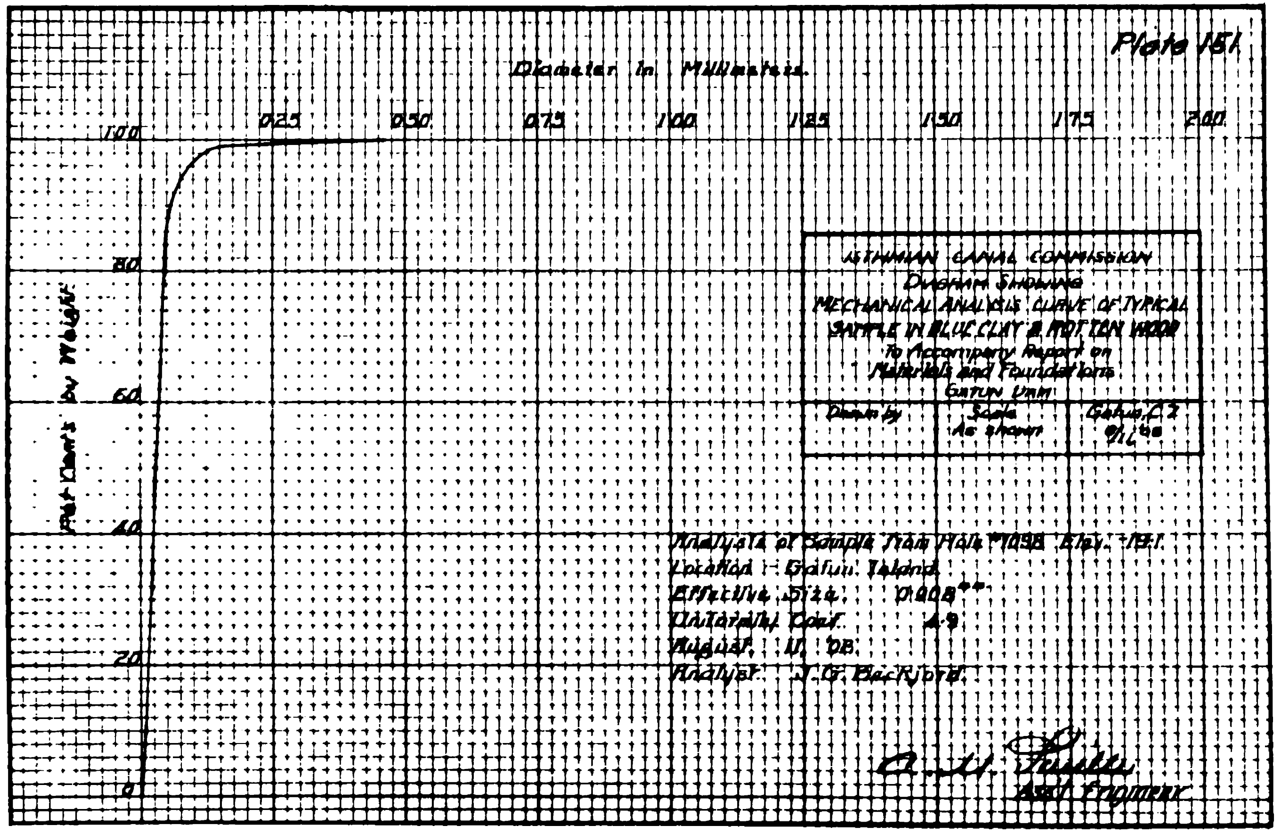


Plate 151
Diameter in Millimeters.
100
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
80
60
40
20
0
Per Cent's by Weight
ISTHMIAN CANAL COMMISSION
Diagram Showing
MECHANICAL ANALYSIS CURVE OF TYPICAL
SAMPLE IN BLUE CLAY & ROTTEN WOOD
To Accompany Report on
Materials and Foundations
Gatun Dam
Drawn by
Scale
As shown
Gatun, C.Z.
9/16/08
Analysis of Sample from Hole #1098 Elev. -19.1
Location - Gatun Island
Effective Size. 0.008
Uniformity Coef. 4.9
August. 11. '08.
Analyst. J. G. Blackford
Ass't Engineer

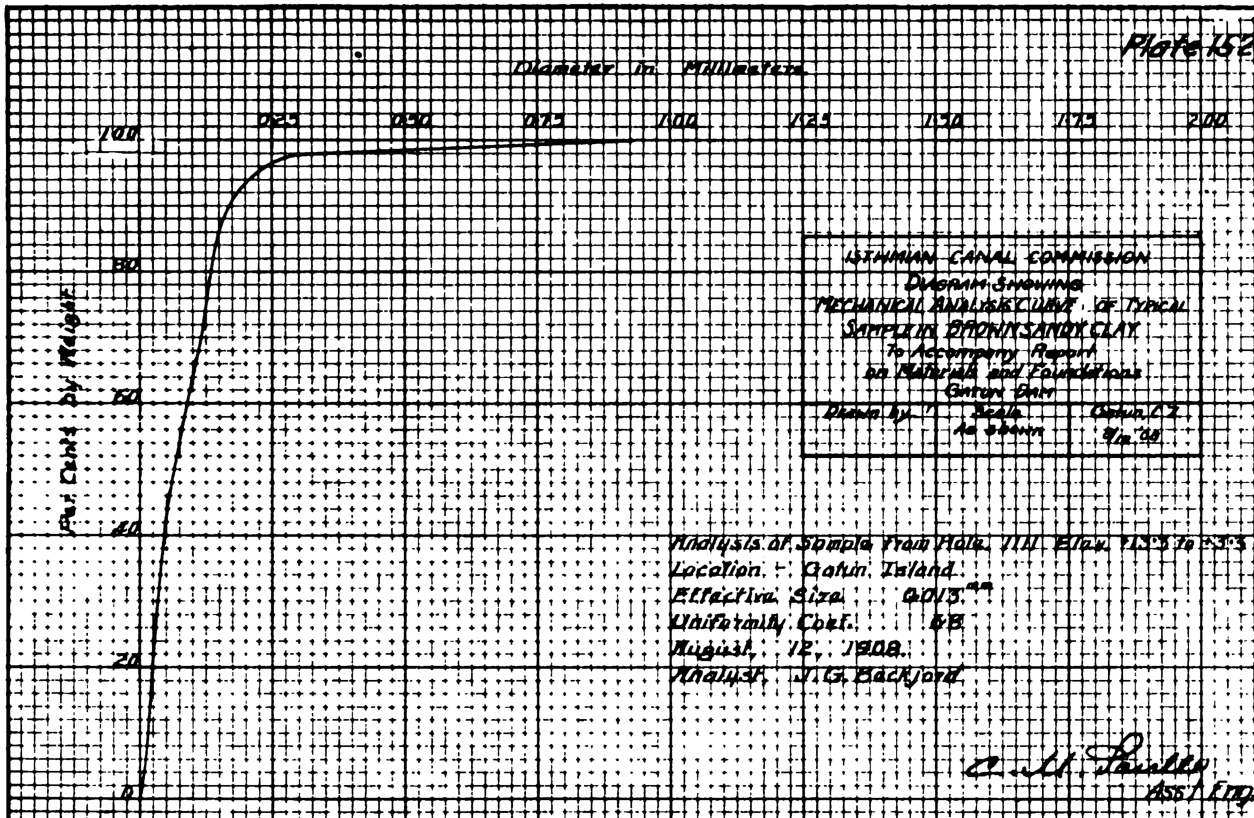


Plate 152.
Diameter in Millimeters
100
.025
.050
.075
.100
.125
.150
.175
.200
80
60
40
20
0
Per Cents by Weight
Isthmian Canal Commission
Diagram Showing
Mechanical Analysis Curve of Typical
Sample in Brown Sandy Clay
To Accompany Report
on Materials and Foundations
Gatun Dam
Drawn by
Scale
As shown
Gatun C.Z.
Analysis of Sample from Hole. 111 Elev. +13.3 to +3.3
Location. - Gatun Island
Effective Size 0.013 mm
Uniformity Coef. 6.8
August, 12, 1908.
Analyst, J. G. Backjord
Asst Eng.

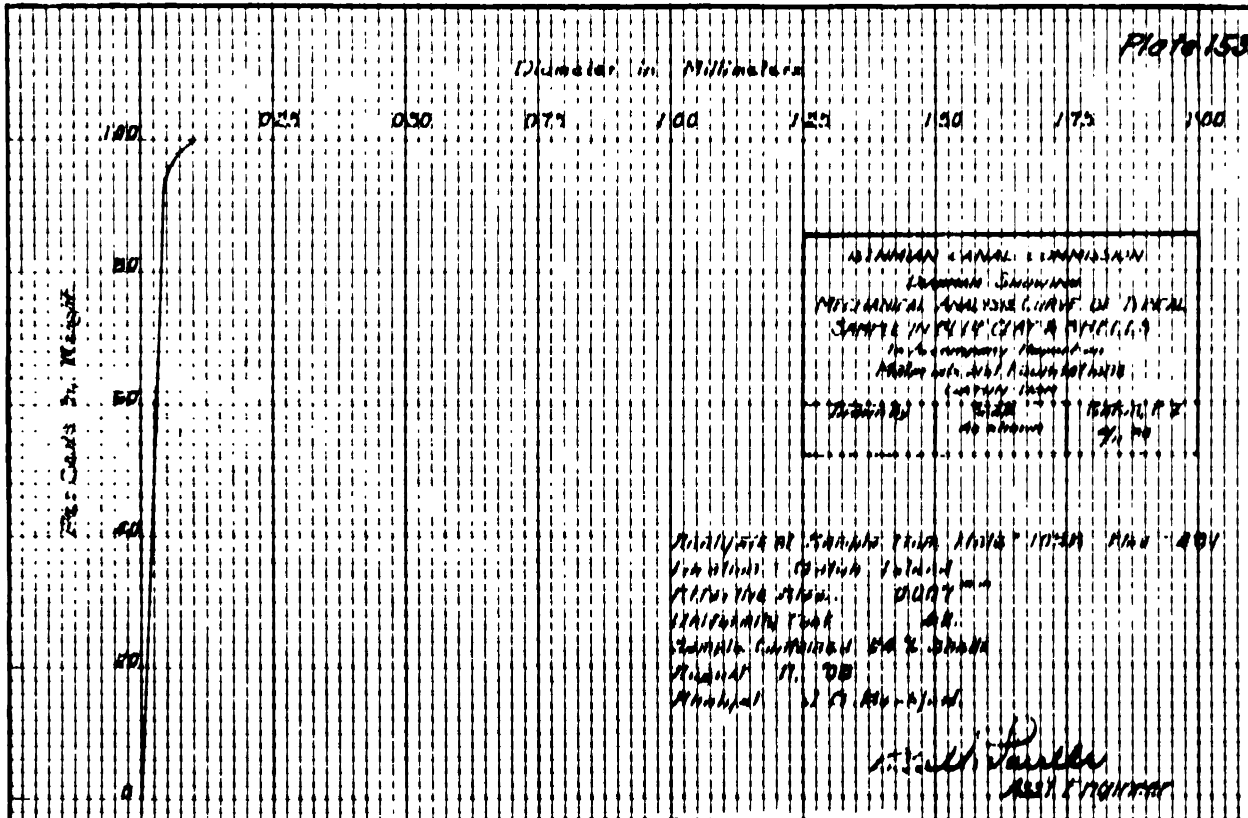


Plate 153
Diameter in Millimeters
.025
.050
.075
.100
.125
.150
.175
.200
100
80
60
40
20
0
Per Cent by Weight
Ass't Engineer

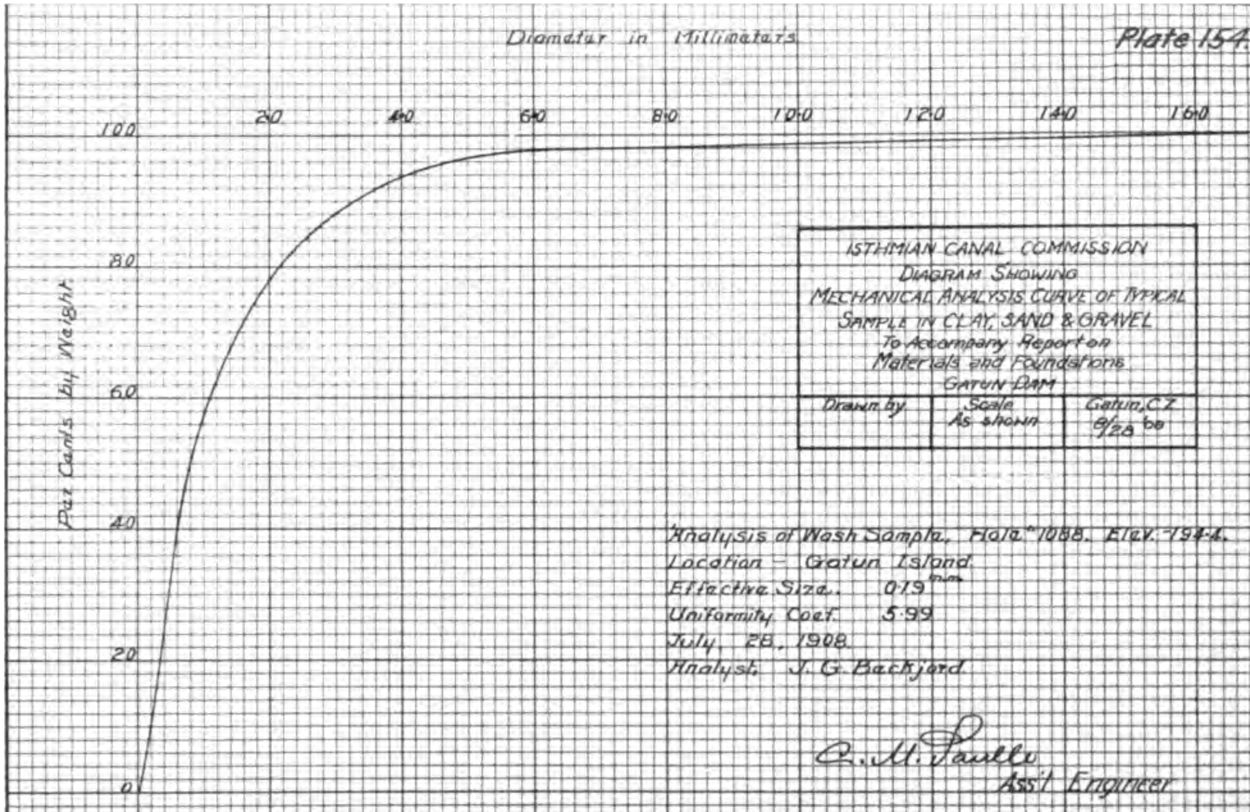
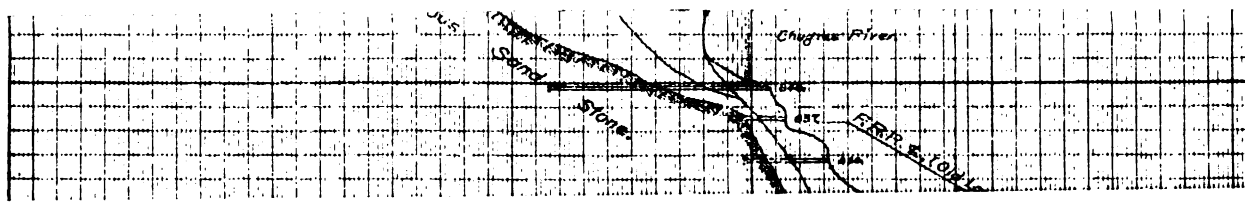


Plate 154.
Diameter in Millimeters
20
40
60
80
100
120
140
160
Per Cents by Weight
100
80
60
40
20
0
ISTHMIAN CANAL COMMISSION
DIAGRAM SHOWING
MECHANICAL ANALYSIS CURVE OF TYPICAL
SAMPLE IN CLAY, SAND & GRAVEL
To Accompany Report on
Materials and Foundations
GATUN DAM
Drawn by
Scale
As shown
Gatun, C.Z.
8/28 '08
Analysis of Wash Sample. Hole # 1088. Elev. -194.4.
Location — Gatun Island
Effective Size. 0.19 mm
Uniformity Coef. 5.99
July, 28, 1908
Analyst, J. G. Backjord
Ass't Engineer


Chagres River
Sand
Stone.

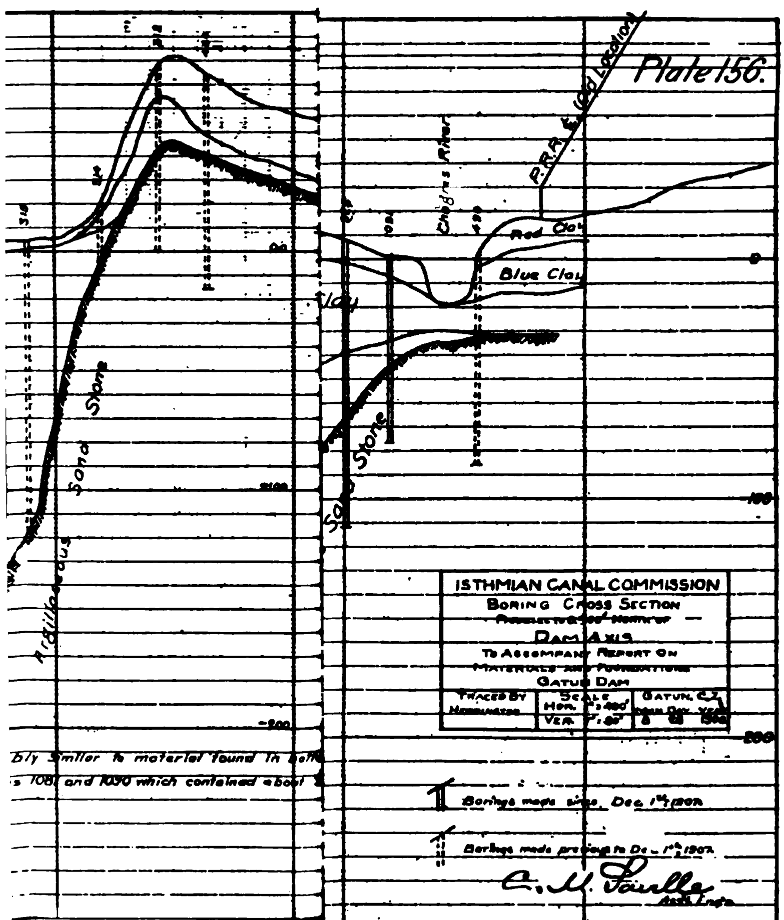


Plate 156.
P.R.R. E (Old Location)
Chagres River
Red Clay
Blue Clay
Clay
Sand Stone
Argillaceous Sand Stone
0
100
200
ISTHMIAN CANAL COMMISSION
BORING CROSS SECTION
DAM AXIS
TO ACCOMPANY REPORT ON
MATERIALS AND FOUNDATIONS
GATUN DAM
TRACED BY
SCALE
HOR.
VER.
GATUN, C.Z.
Borings made since Dec. 1st 1907
Borings made previous to Dec. 1st 1907

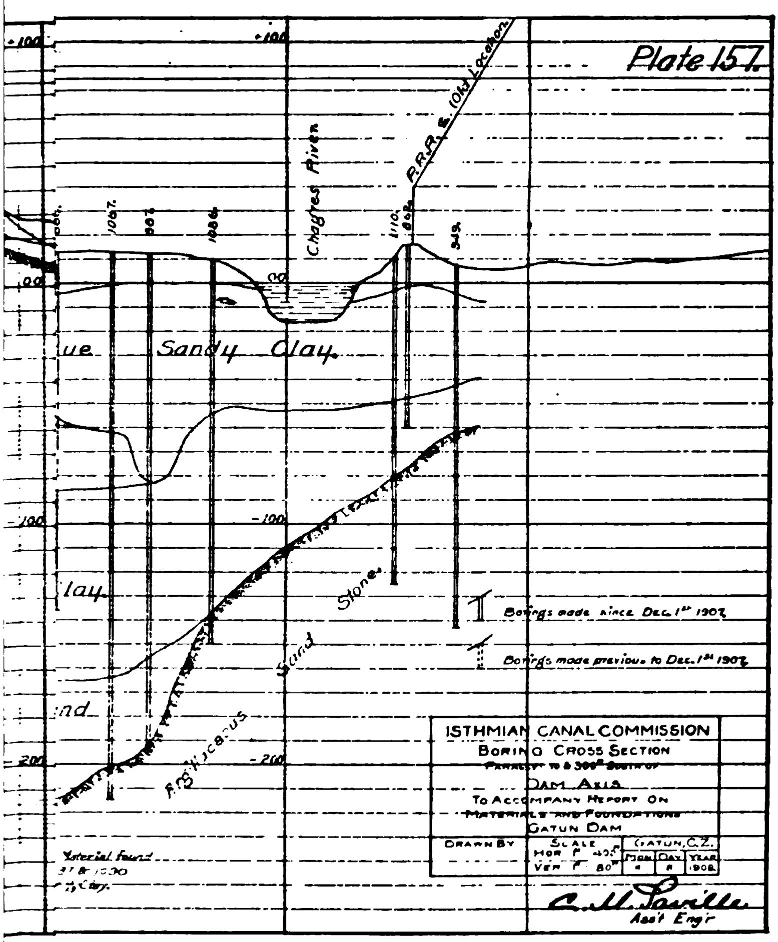
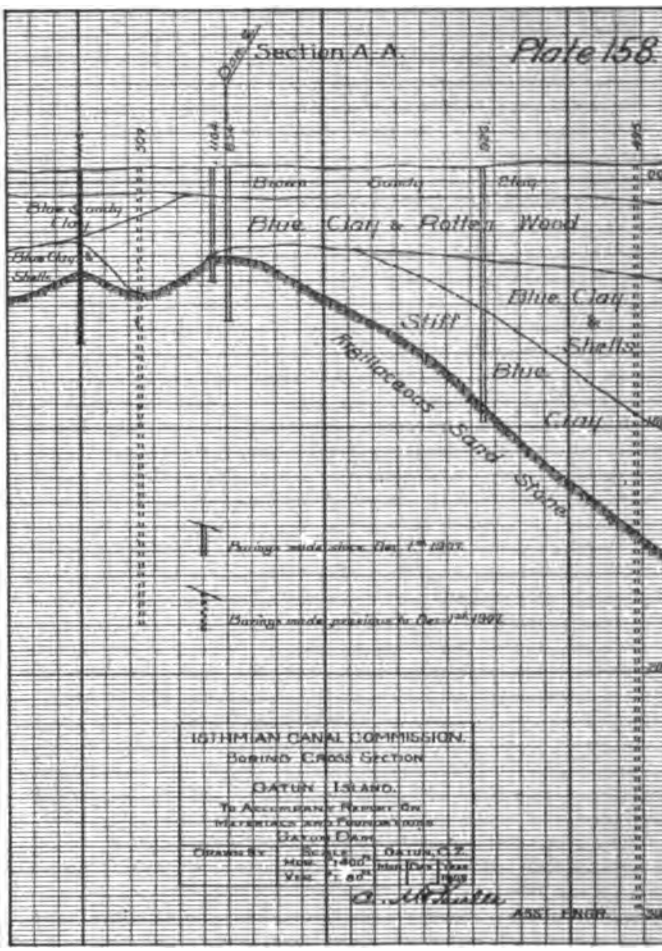
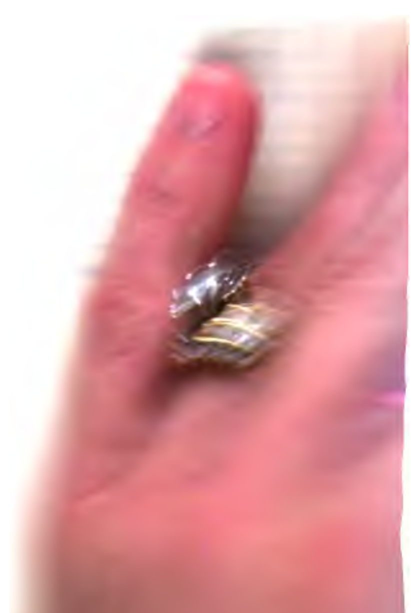
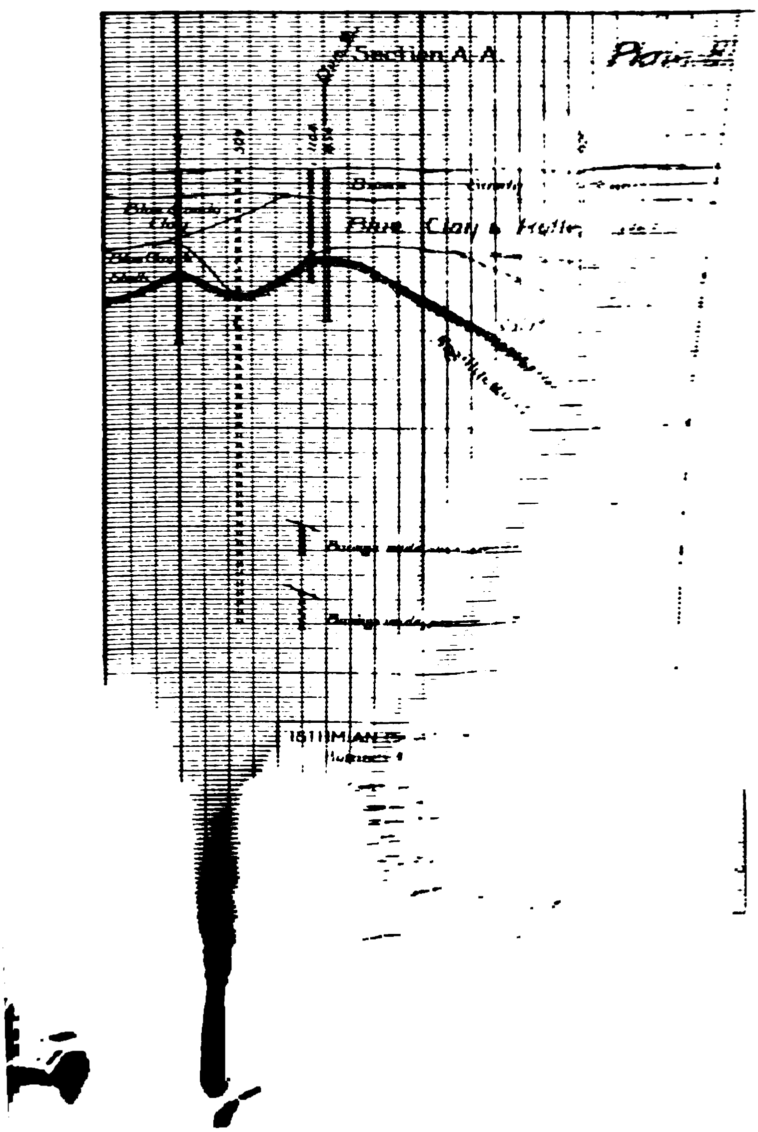


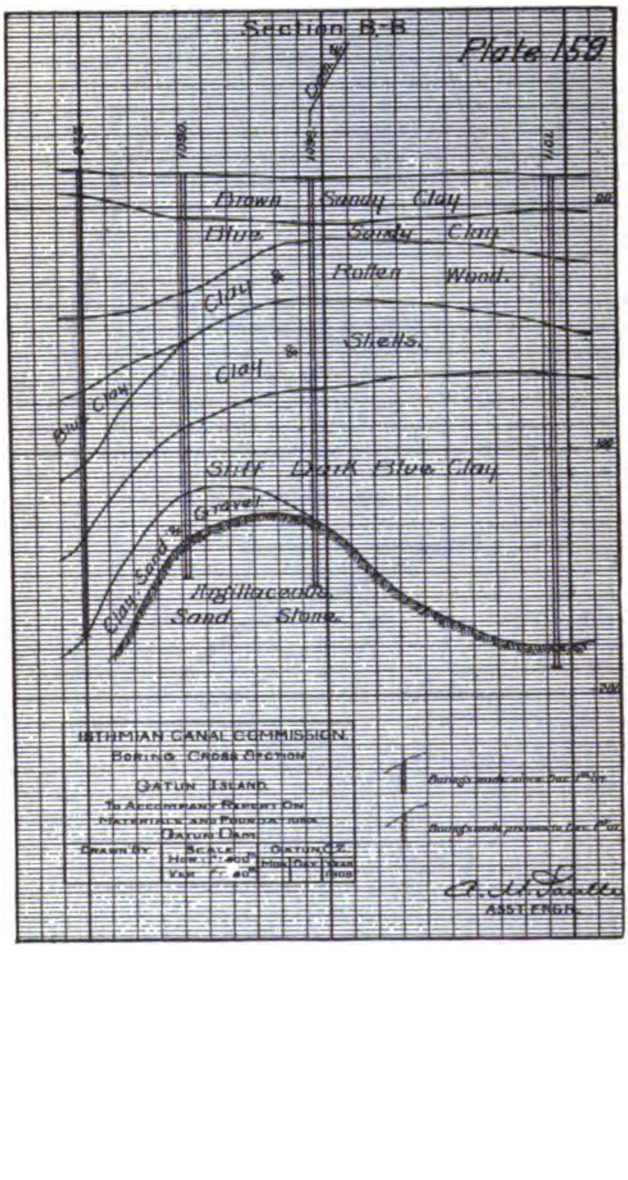
Plate 157.
+100
+100
Chagres River
P.R.R. (Old Location)
1007.
907.
1086.
1110.
909.
349.
0.0
0.0
ue Sandy Clay.
-100
-100
lay.
Stone.
Sand
nd
-200
-200
Borings made since Dec. 1st 1907.
Borings made previous to Dec. 1st 1907.
ISTHMIAN CANAL COMMISSION
BORING CROSS SECTION
DAM AXIS
TO ACCOMPANY REPORT ON
GATUN DAM
DRAWN BY
SCALE
GATUN, C.Z.
MON. DAY YEAR
1908
Ass't Engr

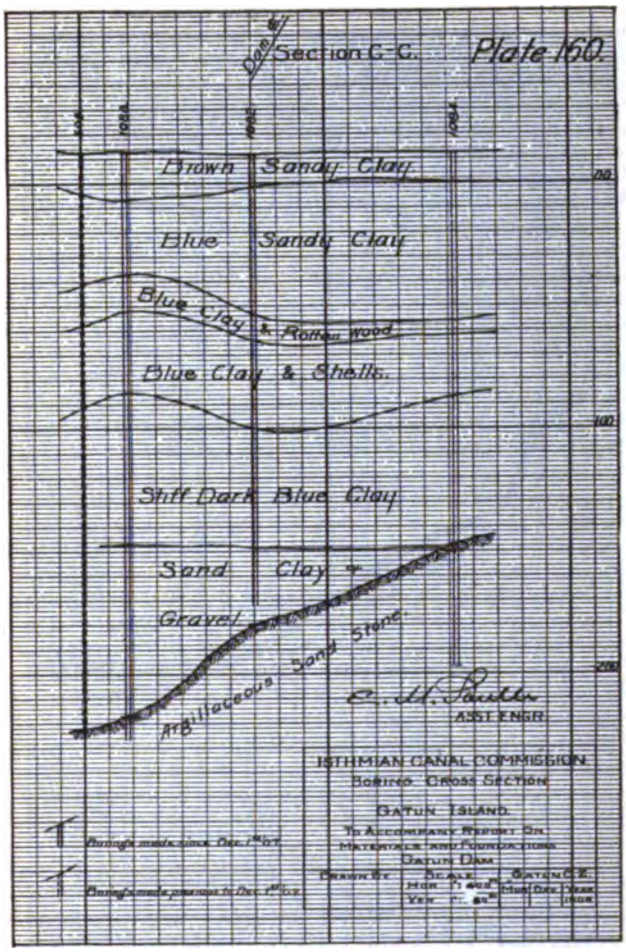

Section A-A.
Plate 158.
Brown Sandy Clay
Blue Sandy Clay
Blue Clay & Rotten Wood
Blue Clay & Shells
Blue Clay & Shells
Stiff Blue Clay
Argillaceous Sand Stone
Borings made since Dec. 1st 1907.
Borings made previous to Dec. 1st 1907.
ISTHMIAN CANAL COMMISSION.
Boring Cross Section
Gatun Island.
To Accompany Report On
Materials and Foundations
Gatun Dam
Drawn By
Scale
Gatun, C.Z.
ASST. ENGR.



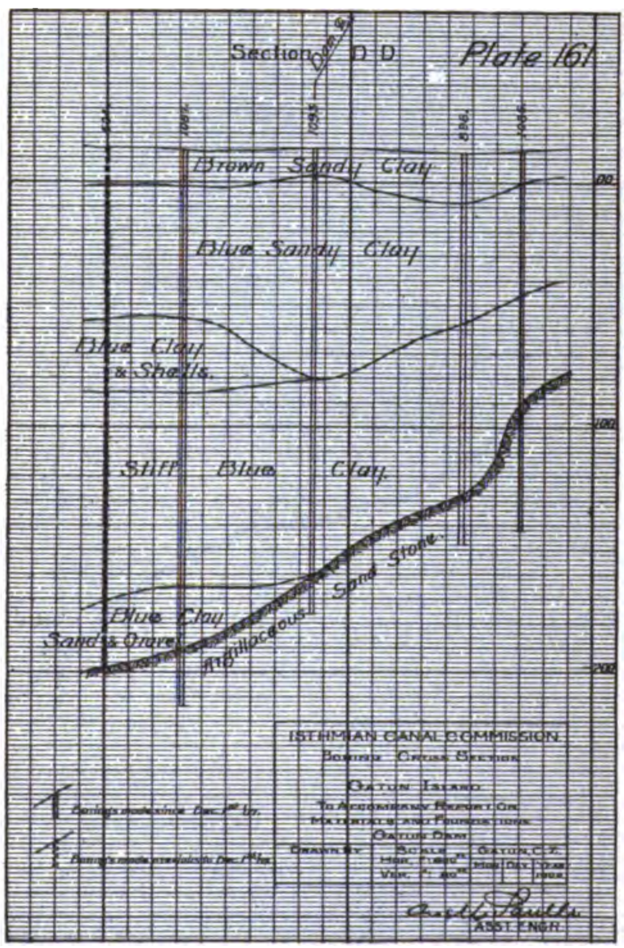


Section A-A.


Section B-B
Plate 159
Brown Sandy Clay
Blue Sandy Clay
Clay & Rotten Wood.
Clay & Shells.
Blue Clay
Stiff Dark Blue Clay
Clay Sand & Gravel
Argillaceous Sand Stone
ISTHMIAN CANAL COMMISSION.
Boring Cross Section
Gatun Island.
To Accompany Report On
Materials and Foundations
Gatun Dam.
Drawn By
Scale
Gatun, C.Z.
Mon.
Day
Year
1908
ASST. ENGR.



Section C-C.
Plate 160.
Brown Sandy Clay
Blue Sandy Clay
Blue Clay & Rotten wood
Blue Clay & Shells.
Stiff Dark Blue Clay
Sand Clay &
Gravel
Argillaceous Sand Stone.
ASST ENGR.
ISTHMIAN CANAL COMMISSION
Boring Cross Section
Gatun Island.
Scale
Gatun C.Z.


Section D D
Plate 161
Brown Sandy Clay
Blue Sandy Clay
Blue Clay & Shells.
Stiff Blue Clay.
Blue Clay
Sand & Gravel
Argillaceous Sand Stone
ISTHMIAN CANAL COMMISSION
Boring Cross Section
Gatun Island
To Accompany Report on
Materials and Foundations
Gatun Dam
Drawn By
Scale
Gatun, C.Z.
ASST. ENGR.

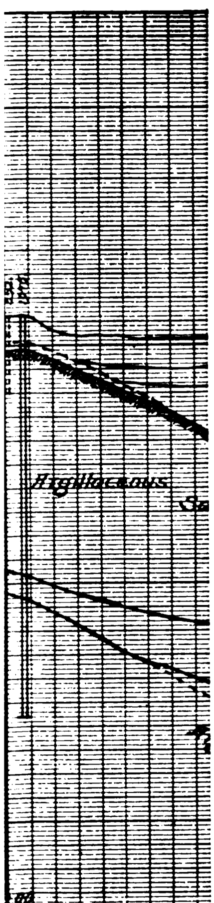
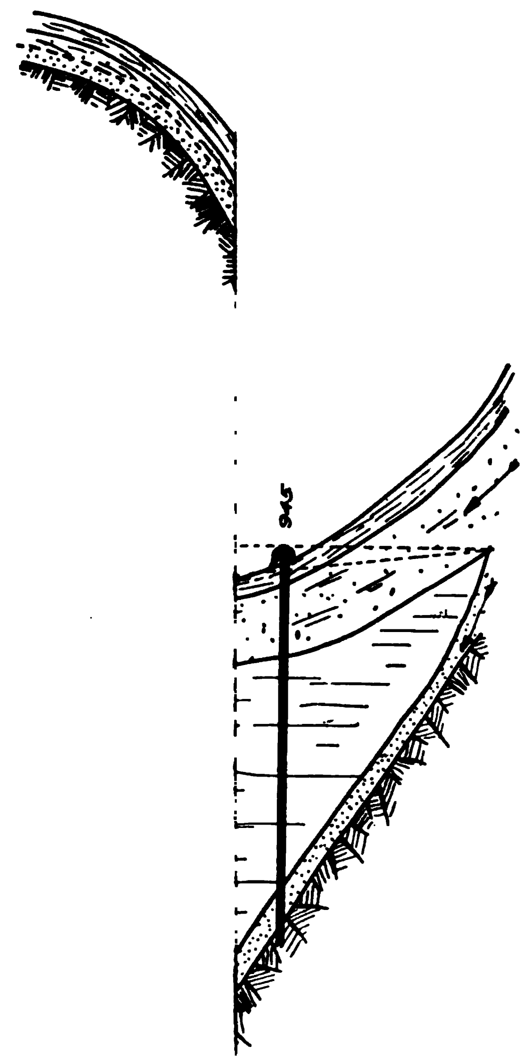
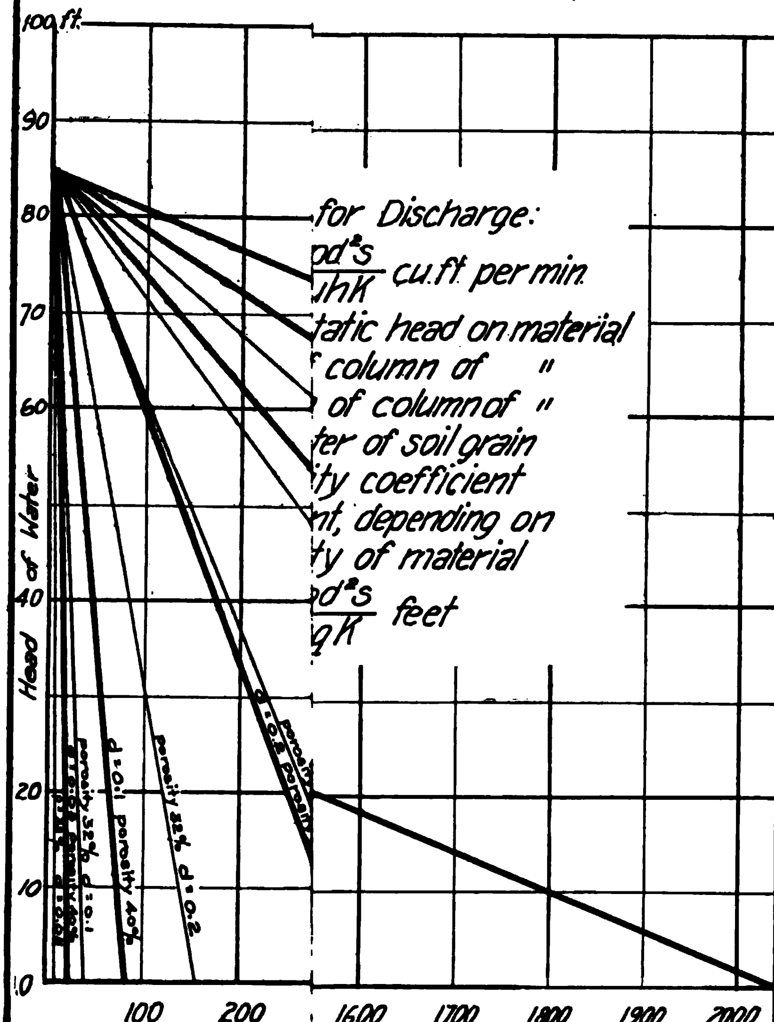

Argillaceous

Plate 166.



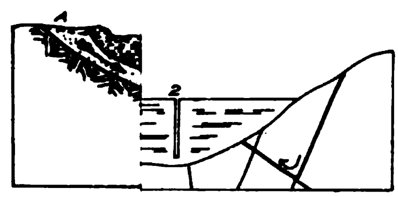
Paulle
Ass't Eng'r

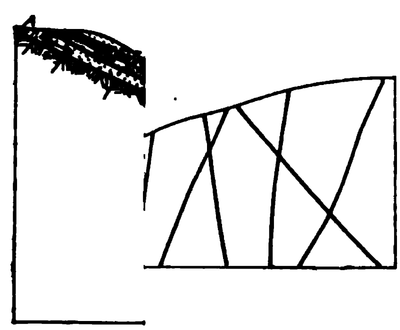
Plate 167.



M. Saville
Ass't Eng'r

Plate 168.





Annual Rep

. M. Saville
Ass't Eng'r

Plate 169.

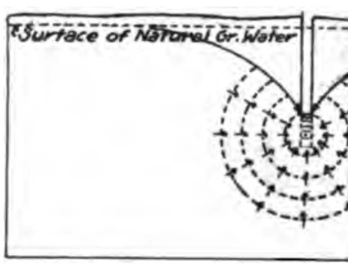


Fig. 1

Annual Report of State Geolog[y]

P. 169

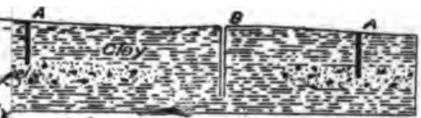


Fig. 7

Fig. 2

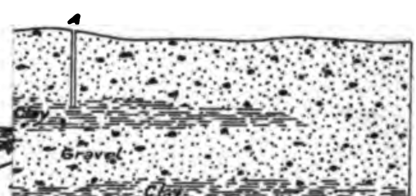


Fig. 8

Fuller's W.S. & I. paper No. 14[...]

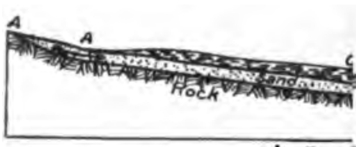


Fig. 3

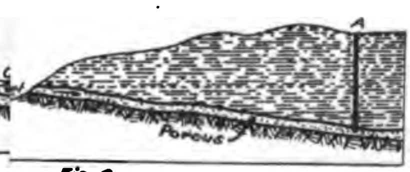
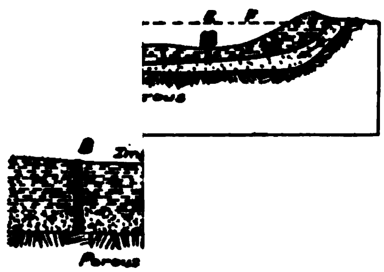
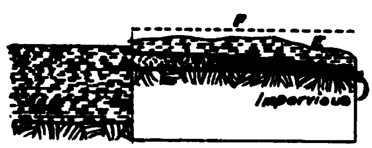


Fig. 9

[signature]
Ass't Eng'r

Plate 170.





Darton, New Jersey, 1898

Asst Eng'r

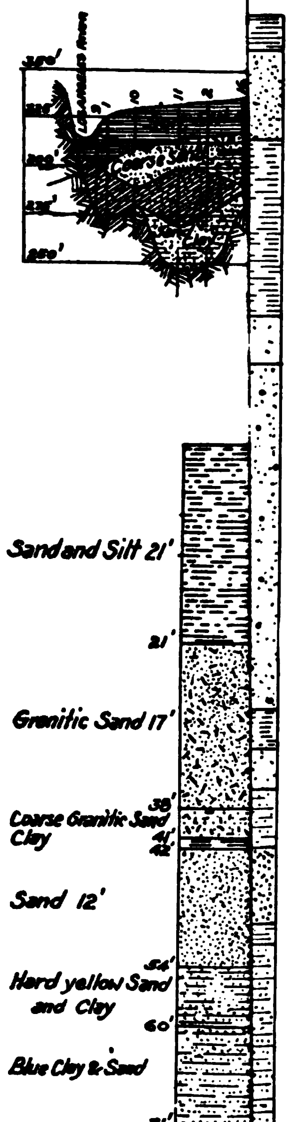
Plate 172.

TABLE SHOWIN 5' HIGH AND 1' THICK, COMPOS-
ED OF T Temperature 85°F

Ordinary of Nrs.	Velocity in feet per min.
Silt and Cl	.0000116
	.0000379
Very fine S	.0003878
	.0009475
Fine Sand	.001551
	.003790
Medium Sa	.009695
	.02369
Coarse San	.03878
	.09475
Fine Gravel	.1551
	.3790

Plate 173.

No. 16



0'

	Number of Test	Direction of Underflow	Velocity of Underflow in feet per Day
21'	10	—	—
25'	9	S 8° E	96.0
29'	8	—	—
33'	7	—	—
37'	6	—	—
41'	5	—	—
45'	4	S 22° W	4.0
49'	2 & 3	—	—
52'	1	—	—

56'

Fig. 4

Vertical scale

10 20 30

M. Saville
Ass't Eng'r

APPENDIX F.

REPORT OF LIEUT. COL. H. F. HODGES, CORPS OF ENGINEERS, U. S. ARMY, ASSISTANT CHIEF ENGINEER, ON DESIGNS FOR LOCK GATES AND MOVABLE DAM.

CULEBRA, CANAL ZONE, *July 24, 1908.*

SIR: I have the honor to submit the following report of progress on the design for the lock gates and movable dam during the fiscal year ending June 30, 1908. This work was placed under my charge by your circular dated February 21, 1908.

LOCK GATES.

The preparation of the design for the gates for the different locks on the canal is under the direct charge of Mr. Henry Goldmark, designing engineer. Prior to July 1, 1907, the work accomplished consisted mainly in a detailed preliminary design of the rolling gate for the 100-foot lock. A general lay out was also made of a mitering gate for the 100-foot lock.

Beginning in June, 1907, the design of the mitering gates (for a lock of the same width) was taken up in detail. The theory of the stresses in the web plates was studied, and formulæ were also obtained for calculating the required flange sections by a direct method instead of the usual method by trial.

The anchorages, including the steel castings in the top of the walls, were designed in detail, and a general lay out made for the La Boca locks. In connection with the designs of the anchorage preliminary sketches and weight computations were made for all gates on the canal. The most important details were then taken up in succession, viz, the hollow quoin, the quoin and miter posts, the sill, the connection of gate to anchorage, the internal structure of leaf, and the question of air chambers.

In each case many alternative designs were fully studied. Those that proved undesirable were discarded and the best types developed to obtain thoroughly satisfactory details.

In view of the proposed change in the width of the locks comparative estimates were made of mitering as well as rolling gates for widths of 100, 110, and 120 feet. An extended comparative study was made of cylindrical and straight-backed gates for 100, 110, and 120 foot locks, with two different angles of sill.

An investigation was also made of the effect of the vertical stiffness in mitering lock gates on distribution of the stresses. A general theory was developed and applied to the gates for the canal.

The studies of typical details have been revised and extended; it is believed that all essential parts have been satisfactorily covered.

At present the status of the work may be given as follows:

The general arrangement of gate leaf and masonry recesses for the 110-foot locks have been worked out. An economical vertical spacing, involving only three different panel heights for all gates on the canal, has been determined, and the resultant loadings on all these horizontals calculated. The actual cross sections of these girders have also been practically ascertained. The same may be said regarding the sheathing plates and their intercostals.

The typical details of the hollow quoins, quoin and miter posts, and their internal bracings, as well as the bearing pieces and adjustments, the anchorage castings, the pintle, pintle castings, etc., have been drawn out in detail. These details are believed to be satisfactory solutions of the problems involved in each case. Some of them are in pencil only and all must be redrawn with the rivet and bolt spacing arranged for use in the several gate sizes.

The work remaining to be done to complete the plans of the mitering gates is approximately the following: Dimensions of cross sections in girders, sheathing plates, intercostals, etc., to be checked; lengths of cover plates, etc., accurately determined, and all details modified to correspond to individual cases.

It should be noted that the upper parts of all the gates for 35 to 40 feet will be identical; that there will be little if any difference in the pintle castings, sills, or anchors. Hence many of the drawings will be simply outlined, the details being drawn but once.

As noted above, a detailed study for a rolling gate designed to withstand water pressure was worked out. In addition to this a variety of other forms of gate have been studied, which appeared to possess certain advantages as barrier gates to be used at the downstream end of the summit level lock.

The results of these studies seem to show that a skeleton rolling gate not adapted to resist water pressure will be the best form for use in this place.

EMERGENCY DAM.

Mr. David Molitor, designing engineer, has been in immediate charge of the design for the movable dam and has prepared the plan outlined below.

The study was undertaken about June 1, 1907, at first in a general way, in order to determine the type best suited for the purpose and the peculiar climatic conditions prevalent on the Isthmus.

Any structure which would be continually under water was deemed unsuitable on the grounds of inaccessibility for painting and making repairs; also because rapid deterioration was certain to take place. Attention was therefore directed at once to the bridge type of dam.

An investigation of the hydraulic conditions of flow through the canal following the destruction of a lock gate has shown that the velocity of the current at the upper approach to the Gatun lock flight would be about 23.5 feet per second with water at a depth of about 50 feet.

With this condition as a basis, a structure is being designed which promises to be suitable.

The design has progressed to a state where all general features are definite; a few details will require some further study, and numer-

ous general and detail drawings remain to be made, though much of the work has been finally completed, and everything has been planned as shown on the drawing herewith. (Plate 174.)

There are two vertical trusses forming a counterweighted swing bridge on which are hung a horizontal truss, six pairs of wicket girders, and six sets of gates.

The horizontal truss is fastened to one side of the downstream vertical truss and the wicket frames are attached to the upstream chord of the horizontal truss at panel points. The bottom ends of the girders are hung from the upstream overhang of the swing span. This affords a most suitable system for manipulating the lowering, which is to be done from a central power to be located on the counterweight.

In operating, the current is checked by successively lowering the first set of gates across the canal and then proceeding to the second set and so on, thus gradually converting the dynamic energy into static head. According to this plan, the greatest difficulty in the way of wicket dams is obviated by obstructing the flow from the bottom of the canal upward instead of by vertical wickets, which latter method reduces the final opening to a vertical slot with water pouring through under maximum head.

Eight sheets of drawings are completed, showing the design of the wicket girders, the gates and the horizontal truss system, including all details connected with these elements.

The sway and lateral system is all sketched, but not finally dimensioned for all panels of the structure.

The vertical trusses are planned and their preliminary details worked out, but as the weights of all other parts of the structure must be accurately known before computing the final stresses in the vertical trusses, these latter must necessarily be designed last.

Attention is invited to the novel style of truss system here employed for the first time in this country. It affords the combined advantages of short panels, short members, and rigidity, and enables carrying all stresses, due to maneuvering of wickets, in one plane.

Respectfully,

H. F. Hodges,
Lieutenant-Colonel, Corps of Engineers, U. S. Army,
Assistant Chief Engineer.

Lieut. Col. Geo. W. Goethals,
Corps of Engineers, U. S. Army,
Chairman and Chief Engineer Isthmian Canal Commission,
Culebra, Canal Zone.

APPENDIX G.

REPORT OF THE PANAMA RAILROAD COMPANY.

COLON, PANAMA, *August 7, 1908*.

DEAR SIR: Herewith I send you an extract from my annual report.

Yours, truly,

H. J. SLIFER,
General Manager,
Panama Railroad Company.

Lieut. Col. GEO. W. GOETHALS, U. S. Army,
Chairman and Chief Engineer Isthmian Canal Commission,
Culebra, Canal Zone.

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OFFICE ENGINEER WORK.

The engineering force in the office consisted of an office engineer, four or five draftsmen, and a blueprint boy; all designing, mapping, caring for, and indexing of records, and making of blueprints being done in the office.

The work of making alignment maps, profiles, and station plats was taken up and progressed with several interruptions, due to current work, until there are now a complete profile showing top of rail elevation and alignment, and a complete alignment map of both the operated and relocated line, scale 1 inch = 400 feet, and station plats of all station lay outs on the operated line. These latter plats are on scale of 1 inch = 100 feet, and show every switch, cross-over, signal station building, etc. They are kept revised whenever any changes in the lay out are made, and therefore are of great value in showing the exact conditions at each station. New maps of Colon and Cristobal have been made.

Considerable time has been spent on map work on the relocated line. A general map showing both the relocated line and the operated line is about 75 per cent completed. Monthly estimates received from the engineer of construction were summarized and a monthly report of work made. Progress profiles of all work were kept, a copy being submitted with each monthly report.

The maps, profiles, and other drawings have been filed in drawers, a card index being kept. The office contains about 300 catalogues, of which a card index is also kept. All notebooks are also indexed.

The first bridge design was made for Gamboa bridge No. 309, on the relocated line. Design was completed July 9 and presented no unusual features except the tapper span, which was used at the north end of the curve to reduce the distance between centers of webs on girders, without showing a break in their line of continuity.

Bridge No. 44, on the operated line, was known to be unsafe and several schemes for strengthening the old girders were submitted. The one finally approved consisted in replacing the three north spans with three new through plate girder spans and placing steel bents under the centers of the three south spans. Details of the new girders and bents were then drawn. The only unusual feature in this bridge is that the floor beams are placed about midway of the webs, instead of at the bottom. This was done in order to elevate the floor of cars above the top of the girders, and thus allow rocks falling from spoil cars to be thrown over the girders instead of against them.

Plans were drawn for steel viaduct across Gatuncillo Valley, 6,72 feet long and 80 feet high to the top of rail. A solid floor was designed for this viaduct, as well as a footbridge and hand-car retreat.

A highway bridge over the relocated line at Gatun was designed to be built from old French material. This is the only skew bridge which has been designed in the office.

Ten-by-ten arch concrete culvert for the relocated line at Gatun and 20-by-24-foot arch culvert, to be used at two openings on the relocated line at Pedro Miguel and Miraflores, have been designed.

Section for the tunnel at Miraflores and portals for same have been designed.

The work of making standards was taken up early in the year. As the gauge of the road is not standard, a great number of foreign standards which might otherwise have been adopted were useful only as guides to good practice. The following standard drawings have been made and others are being added to the list as necessity demands:

STRUCTURES.

108-foot through-plate girder.
103-foot through-plate girder.
60-foot deck-plate girder.
45-foot deck-plate girder
80-foot through-plate girder.
40-foot deck-plate girder.
30-foot deck-plate girder.
Rail top box culvert.
Concrete sidewalk.
Temporary shanties.
Oil box.

TRACK STANDARDS.

No. 10, 90-pound turnout.
No. 9, 90-pound turnout.
No. 7, 90-pound turnout.
No. 12, 70-pound turnout.
No. 10, 70-pound turnout.
No. 9, 70-pound turnout.
No. 8, 70-pound turnout.
No. 7, 70-pound turnout.
No. 6, 70-pound turnout.
No. 8, 56-pound turnout.
No. 7, 56-pound turnout.
No. 6, 56-pound turnout.
No. 5, 56-pound turnout.
90-pound rail and continuous joints.
90-pound rail brace.
90-pound frogs.
90-pound switch points.
90-pound tie plates.
90-pound sheared angle bar.
90-pound guard rail.
90–70-pound compromise joints.
70-pound switch point.
70-pound sheared angle bar.
70-pound tie plate.
70-pound rail and angle bar.
70–56-pound compromise joints.
55-pound frogs.
High switch stand.
Low switch stand.
Track spike.
30-pound rail and angle bar.
55-pound switch points.

In addition, there has been the usual amount of miscellaneous drawings to be made. The blueprint work requires about 14 yards of paper per day, prints being made in this office for all other departments as required.

ENGINEERING DEPARTMENT.

MAINTENANCE.

The total expenses have increased $164,000 over 1907, due principally to large forces necessary to keep up new track on fills and to heavy rail, tie, and switch renewals. The coming year will show a decrease in maintenance expense because physical conditions are excellent and the second main-track embankment has had most of its settlement.

TRACK DEPARTMENT.

The second main line has been completed and is now in use between milepost 7½ and milepost 36½, milepost 40¾ and milepost 46½, and 1 mile of the La Boca branch, a total of 35⅝ miles of double main track.

During the year 45,000 ties, 52,000 cubic yards of gravel, and 25,000 cubic yards of crushed rock have been used.

New side, house, and commissary tracks, laid with 70-pound steel, have been constructed as follows:

Location.	Sidetracks.		House tracks.		Commissary tracks.		Total.	
	Number.	Length.	Number.	Length.	Number.	Length.	Number.	Length.
		Feet.		*Feet.*		*Feet.*		*Feet.*
Ahorca Lagarto			1	911			1	911
Frijoles	1	236					1	a 236
San Pablo	1	1,202					1	1,202
Gorgona	1	1,450					1	1,450
Las Cascadas					1	1,100	1	1,100
Culebra			1	725	1	590	2	1,315
Pedro Miguel					1	575	1	575
Miraflores	1	1,120					1	1,120
Total	4	4,008	2	1,636	3	2,265	9	7,909

a Built in 1907, 1,500 feet.

At Mount Hope a material yard containing 12,210 feet of track was laid for facilitating the handling of material at the Isthmian Canal Commission material and store yard. The cost of this work was borne by the Isthmian Canal Commission, for whose use it was built.

At Colon the temporary coach yard was taken up and a permanent one, containing 1,725 feet of track, built. The old terminal has also been removed and the ground filled in for quarters. This provides 50 of the choicest building lots in Colon, lying along the beach between the church and the hospital.

The old Panama yard has been entirely remodeled in order to accommodate increased passenger business and facilitate the handling of freight. As now being built, the yard consists of an 8-track diamond 1,300 feet long, a terminal yard consisting of a new turntable, engine house, water station, cinder pit, and machine shop on one side of the diamond and four industry tracks on the other side, a 4-track passenger yard and 3 pairs of team and freight-house tracks 700 feet long. The team tracks and freight house are located alongside a new street that has been opened from the end of Balboa avenue, at Sixteenth

street, to the passenger depot. The work necessitated laying the following amount of track:

	Feet.
New 70-pound steel	7,740
S. H. 70-pound steel	11,510
S. H. 56-pound steel	3,450
Total	22,700

Work is 90 per cent complete.

Owing to the heavy dirt-train traffic between Las Cascadas and Tabernilla it has been necessary to replace the 70-pound steel on curves and short tangents on this part of the line with 90-pound rail using continuous rail joints. Details follow:

Track relaid:		
Southbound	miles	8.74
Northbound	do	9.36
Cross-overs relaid, No. 10	do	12.00
Turnouts relaid:		
No. 10	do	32.00
No. 7	do	2.00
Total cost, new material		$122,589.40
Value S. H. material, recovered		51,155.82
Net cost of material		71,433.58
Total labor cost		30,712.56
Total cost		102,146.14

This was an Isthmian Canal Commission charge.

The following changes have been made in the main line:

Juan Grande cut-off:		
Length, mile post 27½ to 28¼	feet	3,300
Saving in distance	do	748.5
Saving in curvature		104° 34
Total cost		$30,414.44
Paraiso canal crossing:		
Length, mile post 39¼ to 40½	feet	6,600
Increase in distance	do	398
Increase in curvature		15° 25
Total cost		$54,089.85

The new canal crossing was necessary because the old line passed through the Pedro Miguel lock site. Both the Juan Grande and Paraiso line changes were in the interests of canal construction and were paid for by the Isthmian Canal Commission.

Besides these two line changes the grade was raised on old alignment at Rio Grande reservoir, Barbacoas, and between Tiger and Lion hills, as follows:

RIO GRANDE RESERVOIR, OCTOBER, 1907.

Grade raised 3 feet at bridge No. 56, which spans the spillway. Average raise of single track for 2,500 feet was 1.3 feet. Purpose was to increase the capacity of the reservoir. Total cost, $1,874.40, borne by the Isthmian Canal Commission.

BARBACOAS, FEBRUARY, 1908.

Grade raised 2.4 feet at bridge No. 44. Average raise of double track for 2,600 feet was 2 feet. Purpose was to give better clearance for extension flat cars loaded with excavated material from Culebra Cut. Total cost, $5,099.60, borne by the Isthmian Canal Commission.

TIGER HILL, MAY, 1908.

Grade raised 4 feet at bridges 25 and 26. Average raise of double track for 3,000 feet was 3 feet. Purpose was to prevent tracks being flooded by back water due to canal operations at Gatun dam. Total expense, $6,100, borne by the Isthmian Canal Commission.

The tonnage of trains was not affected by any of the above grade changes.

The track across the Black Swamp, near Ahorca Lagarto, has always caused trouble in the wet season by settling, but in July, 1907, under the increased number and weight of trains, and the additional weight of the fill for second track, this settlement became rapidly worse and finally at noon, on July 30, 300 feet of double track embankment and both tracks settled about 12 feet. Two pile drivers were used to drive a trestle across the break and traffic was resumed on the morning of August 1, forty-two hours after the trouble occurred. On September 20, 200 feet more of the swamp settled in the same way and was similarly replaced with trestle after forty-eight hours interruption to traffic. In view of the proposed abandonment of the present line across the Black Swamp in about two years, traffic will be carried on by use of the trestle in the meantime.

BRIDGE BUILDING AND DOCK DEPARTMENT.

Twenty-eight bridges, with a total length of 2,763 lineal feet, have been built, as follows:

New main line bridges built July 1, 1907, to July 1, 1908.

Bridge number.	Location.	Length.	Number tracks.	Trestle.	Reason built.
		Feet.		*Lin. ft.*	
13½	Gatun	45	2	90	Replace bridge 13, blocked by Gatun dam.
15	do	163	1	163	Second main track.
25	Tiger Hill	24 32	2	56	Raising track above backwater due to Isthmian Canal Commission work on Gatun dam.
26	do	24 32	2	56	
27	do	24 32	2	56	
28½	Black Swamp	505 565	2	1,070	Replaces fill which settled in swamp.
49	Juan Grande	118	2	236	Juan Grande cut-off.
49½	Gorgona	17	2	34	Replace culvert blocked by Isthmian Canal Commission dump.
50½	Bas Obispo	105	2	210	Isthmian Canal Commission diversion of Obispo River.
61½	Miraflores	16	2	32	To drain river blocked by Isthmian Canal Commission dump.
62½	Corozal	16	2	48	To drain swamp for sanitary department, Isthmian Canal Commission.
	Total		21	2,051	

Other bridges and trestles built July 1, 1907, to July 1, 1908.

Bridge number	Location.	Length.	Reason built.
		Feet.	
55½	Culebra	75	For Isthmian Canal Commission dump opposite Lirio planing mill.
62½	Corozal	16	For Isthmian Canal Commission third track.
63	....do	16	Do.
	Dock 14	150	To place a track along front side of dock.
	Cold storage (Cristobal).	285	For elevated loading track.
	La Boca	170	Two main line bridges on La Boca branch, across Isthmian Canal Commission drainage channel.
	Total	[a] 712	

[a] Seven bridges.

Bridge No. 44, across the Chagres River at Barbacoas, has been strengthened to equal a Cooper E–50 structure, by replacing the three north spans over the river channel with three entirely new spans and by strengthening the three south spans of the old bridge. Both floor system and main girders being weak in the old bridge, it was necessary to provide new floor beams and also to place steel bents under the middle of these spans. As the Chagres floods will not admit of any obstruction in the channel, only the three south or shore spans could be so strengthened. New floor beams were placed in July and August, three new spans were installed in April, and steel bents were placed under the three old spans in May.

In Colon, quarters for 15 families have been constructed, 3 of them being in new buildings and the remainder in remodeled buildings formerly used as storehouse and stable. Five old houses have been moved to new locations, entirely repaired and new plumbing installed. A new 4-room schoolhouse was built, occupying part of the site of the old Colon Terminal, which has been entirely torn down.

New roofs have been constructed for docks 1, 2, and 4, Colon, and a 12-foot addition built on the north side of Dock 4. Total cost of these dock repairs, $38,014.90.

Other work done in Colon includes building fences around docks 1, 2, and 4, to give greater security to freight, and building 2,000 feet of riprap sea wall and 1,000 feet of concrete wall between the Colon light-house and the quarantine hospital, to protect the beach from the action of storms.

In Cristobal a standard building for quarters for 4 families has been built, a paint storehouse and a general storehouse, together with pipe racks, etc., constructed; an addition made to the bakery and laundry buildings, and the cold-storage plant enlarged by moving the offices to a new building erected alongside, refrigerating the second floor, and building an additional ice-making room on the first floor. The boiler and engine rooms were also enlarged to provide power for the additional refrigeration, and to provide space for the Colon electric-light machinery, which will be consolidated with the cold-storage power plant.

The sales room in the Cristobal commissary has been completely remodeled, and the upstairs, formerly occupied by post-office and

court room, made into offices and storeroom. A 40 by 50 3-story addition has been built.

New section houses have been built at Mount Hope, Bas Obispo, and Pedro Miguel. The Gatun station building has been moved back about 40 feet to clear excavation for Gatun dam. In connection with moving old Gatun village, a new church and parsonage have been built. These, as well as the station work, were paid for by the Isthmian Canal Commission.

Water cranes have been installed at Tabernilla and Matachin, a new freight house built at Empire, and the old Miraflores station torn down and moved 500 feet north.

In connection with the remodeling of the Panama yard, the work done by this department includes installing a new 60-foot turntable, erecting a 21,000-gallon steel water tank and a water crane, and constructing a double 30-foot cinder pit. New buildings erected are yardmaster's office and dwelling, engine house, and addition to machine shop and carpenter shop. The old freight houses have been removed and reconstructed so as to make a house 42 by 540 feet, with a shed addition extending the whole length covering two tracks on one side and a team platform on the other side. This team platform is on the east line of the new street which runs from Sixteenth street to the passenger depot. The machine shop has been moved and enlarged, and the engineer's quarters moved and repaired. The passenger station has been remodeled to permit of a ticket-checking system being used, and a concrete platform built long enough to accommodate the increased passenger-train length. An 8-foot picket fence 3,000 feet long has been built around the entire yard, to give greater security to freight and to cut down expense for watchmen.

CONSTRUCTION OF RELOCATED LINE.

The relocated line of the Panama Railroad was made necessary by the plans of the Canal Commission for building an 85-foot level lock canal. The old Panama Railroad will be used from Colon as far as Mindi (5 miles), at which point the new location begins. From here the Panama Railroad seeks its own location as far as Bas Obispo, where it enters the Culebra Cut and is carried through this cut as far as Pedro Miguel. From this point the line again finds its own location, and after passing through the Miraflores tunnel it connects with the old Panama Railroad near the Cardenas River, a point near Corozal. It is necessary to maintain the high level from Gatun to Pedro Miguel, but after passing the lock site at Pedro Miguel the grade is dropped about 30 feet, and after passing the tunnel of the ridge opposite Miraflores locks the grade is dropped about 40 feet to connect with the old main line. The only grades, therefore, on the new line are at either end; from Mindi to Gatun, where it rises practically from sea level to elevation 95, and from Pedro Miguel to the old main line at Cardenas River. The remainder of the road is practically a level grade, 10 feet above the lake level. It is benched in on the sidehills, on the eastern side of the Chagres Valley, from 2 to 3 miles from the old Panama Railroad, on what will be the border of the Gatun Lake. The relocated line is being built as a single track.

Construction work was begun in May and June of 1907, during which time numerous connection tracks had been started from the operated line to the relocated line to transfer men, equipment, and supplies for grading purposes. During the months of July and August, 1907, this work of preparation went on very rapidly, many of the connection tracks were completed, and considerable grading was done at certain points on the main line. In the latter part of August, however, orders were received to suspend operations, due to a lack of appropriation for this work, and construction work on a general scale was shut down. A definite policy was outlined to work only at the following designated points, where the construction of the new line would materially aid Canal Commission plans:

1. From Mindi, through Gatun, to Tiger Hill, a distance of 4½ miles.
2. At Gamboa, on the erection of the permanent steel bridge across the Chagres River at the northern end of Culebra cut.
3. From Gamboa north on the construction of approximately 2 miles of the relocated line.
4. At Miraflores on the construction of the tunnel and the two large concrete arch culverts at Pedro Miguel and Caimitillo rivers.

The construction of the relocated line at Gatun was necessary in order to be able to vacate the old Panama Railroad tracks at that point, which will interfere with the construction of the Gatun dam. The construction of the new Chagres River bridge and a few miles of the line connecting with it was necessary in order to furnish an outlet from the Culebra Cut to numerous valleys along the line of the relocation which will afford cheap dump grounds for excavated material from the Cut. In the relocation of the line the Chagres River was crossed at a point about 10 miles farther upstream than the old line crossing at Barbacoas.

This crossing is exactly at the northern entrance to the Culebra Cut at Bas Obispo. Work on the Miraflores tunnel was continued, as time is the largest factor on such a piece of work.

FROM MINDI TO TIGER HILL THROUGH GATUN.

From Mindi, where the relocated line branches off, to the high level of 95 feet at Gatun (2 miles) the road lies on the Colon side of the Gatun dam. These 2 miles of permanent line were built during the year.

A photograph showing the relocated line under construction just south of Gatun is attached. (Plate 175.)

At the same time a temporary line (2.5 miles) was built through what will be the lake region, connecting the high level (95) with the low grade (22) of the old main line at Tiger Hill. This temporary line, however, was almost entirely embankment, and the line so located that the yardage would not be lost, but would in the end become a part of the permanent line. As will be seen from the accompanying photograph (Plate 176), it was necessary to build some of these embankments in two or three decks, due to their immense height (85 feet), and the material used in most part was waste material from the canal.

This section of 4½ miles is now finished and ready for operation. A unique feature of the temporary part of this line is that one of the old wrought-iron girder spans taken out of the main line bridge at Barbacoas was used across a shorter span at the Gatuncillo River.

The attached photograph shows the building of a 10 by 10 foot arch culvert at Gatun. (Plate 177.)

In the construction of the temporary part of this line—from Gatun to Tiger Hill—it developed that the crossing of the valley of the Gatuncillo River was to prove a very difficult problem. From a point of the Gatun hills to Tiger Hill, a distance of 6,500 feet, the relocated line lies on the bottom land on either side of the Gatuncillo River. The elevation of this ground is about 8 feet above sea level, and the original plans were to build an earth embankment 84 feet high, with a wide top and flat side slopes, which figured to contain 4,250,000 cubic yards. It was proposed to haul a great deal of this material from the Culebra Cut. At the time the temporary trestle was started for making this fill soundings were made to determine the character of the bottom, and it developed that there existed an upper crust of 25 feet of clay and sands over very soft clay below, while solid rock was 200 feet below the surface of the ground. The most serious thing is the nature of this soft brown clay, filled with decomposed wood, which occupies the space between the upper layer of hard clay and sand and the solid bed rock.

It was decided at the time this report was made that it was necessary to continue the construction of the temporary line from Gatun to Tiger Hill to complete the connection between Mindi and Tiger Hill, even though a permanent line could not be built. While work on this temporary connection went forward, parties were put into the field to seek a new location which would avoid crossing the Gatuncillo Valley at the point mentioned. These surveys developed the fact that, first, a very good line and Gatuncillo River crossing existed direct from Mount Hope through Monte Lirio to Bohio, but which would have the disadvantage of leaving Gatun on a spur line, and, second, that a line could be secured turning up the Gatun ridge and connecting with the Mount Hope-Bohio line just mentioned.

These lines were taken up and at the same time the construction of a steel viaduct over the Gatuncillo Valley (in place of the immense dump) was considered. The decision reached was that the choice lay between building a steel viaduct over the Gatuncillo bottoms on the present line or taking the new line up the Gatun ridge and crossing the Gatuncillo River farther up at Monte Lirio, on the line as located from Mount Hope.

Later surveys, now under way, have developed the fact that it may be possible to further improve this upper line, by making an entirely different crossing of the Bohio Ridge, and the results of this survey will decide the question of the crossing of the Gatuncillo Valley.

THE NEW GAMBOA BRIDGE.

The approved location for the new Gamboa Bridge called for an opening of about 1,300 feet across the Chagres Valley, at the north end of Culebra cut and high enough to clear the future elevation of Gatun Lake. The bridge is on a curve and connects at each end with a 40-foot berm along the east slope of the canal.

The general plans and specifications were completed July 9, 1907. The bridge was designed for Cooper's E 50 loading and under the specifications of the American Railway Engineering and Maintenance of Way Association. It consists of a 200-foot rivetted truss span

the Warren type for the channel, and 14 80-foot through plate girder spans, of which 9 are on tangent, 1 on spiral, and 4 on a 6° curve. The channel span is 17 feet between the center lines of trusses, and 34 feet between center lines of top and bottom chords, giving a lateral clearance of 7 feet 3 inches from center of track and a vertical clearance above top of rails of 22 feet 8 inches. The tangent girders are 15 feet 6 inches, center line to center line of webs, giving a lateral clearance of 7 feet 1 inch from center of track, while the girders on the curve are 17 feet between center lines of webs to give equal clearance for longest cars. To give an uninterrupted line of webs, a special span is introduced at one end of the curve, with distance between centers of 15 feet 6 inches at one end and 17 feet at the other, the same as adjoining girders. The other end of the curve is at the truss where the wide girders line with the trusses. The least clearance between usual surface of lake (elevation 85), and the steel is 9 feet, which will be reduced to about 7 feet in time of flood. The total weight of steel is 1,105.12 tons, of which 206.6 are in the truss span and the remainder in the 14 girder spans.

Bids were advertised for August 18, and the contract let August 28, 1907, to the Penn Bridge Company, of Beaver Falls, Pa., at $59,600, New York delivery, to begin February 1 and be completed April 1, 1908. This time was later extended one month by the contract.

Foundations.

Diamond and wash drill borings had been made on the proposed site, which showed that it would be impracticable to carry the foundations to solid rock, except at the south abutment. Piers and abutments were therefore designed, founded on grillage piles. The masonry is machine-mixed broken stone concrete, using Rio Grande Superior rock, Panama Beach sand, and Portland cement. The mixture was 1-2-5, being especially rich because the sand used is not first class.

The following photographs are attached:

(*a*) Gamboa Bridge site, after completion of trestle connecting with old French Bridge (Plate 178.)

(*b*) Gamboa Bridge, showing south abutment, first two piers, and cofferdam for third pier. (Plate 179.)

(*c*) Gamboa Bridge, looking south. (Plate 180.)

(*d*) Gamboa Bridge. Placing last member of top chord, channel span. (Plate 181.)

Also, on account of the poor quality of sand, the rock was crushed to pass through a 1¼-inch ring and used "crusher run," thus containing a large proportion of fine broken stone which furnished a substitute for sand. The piers are heavily reenforced with old French rail. All piers were built with a batter of 0.707 inch per foot. The abutments were designed to be buried and have no batter. When the Gatun Lake is flooded all grillage piles will be far beneath the water line, but as it will be some five or six years before this takes place creosoted piles only were used for foundation. The accompanying table gives details of size and construction of the various piers and abutments.

Table showing size and construction of piers and abutments for bridge 309, Gamboa, Panama Railroad relocated line.

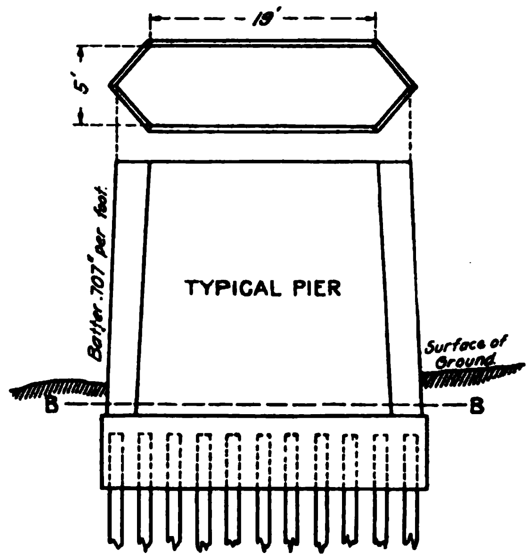
Pier No. 1.	Top dimensions.[a]	Concrete.		Reinforced steel.	Creosoted piles.		Elevation.					Dates.		Remarks.
		Class A.[b]	Class B.[c]		Number.	Total length.	Ground.	Bottom concrete.	Cut-off.	Top footing.	Top pier.	Pile driving completed.	Concreting completed.	
		Cubic yards.	*Cubic yards.*	*Tons.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*			
South abutment.	4 feet 3 inches by 20 feet.	3.2	202.8	5.58	......	....	80.5	59.7	....	67.1	97.58 93.12	....	Oct. 8, 1907	Top back wall, 97.58, founded on rock.
1	5 feet by 19 feet	15.9	173.5	6.00	36	796.4	67.1	61.12	63.62	66.13	93.12	Sept. 25, 1907	Oct. 25, 1907	
2	5 feet by 19 feet	15.9	192.1	6.75	40	1,095.6	66.0	57.0	61.63	64.13	93.12	Oct. 1, 1907	Nov. 7, 1907	
3	6 feet by 21 feet	26.4	414.4	12.51	85	2,573.8	53.6	42.4	48.0	50.0	93.12 91.22	Oct. 24, 1907	Jan. 21, 1908	Truss span shoe at 91.22.
4	6 feet by 21 feet	26.4	478.5	19.76	114	3,012.6	46.3	38.7	45.2	47.2	91.22 93.12	Jan. 4, 1908	Mar. 5, 1908	Do.
5	5 feet by 21 feet	20.1	268.3	8.51	60	1,078.3	61.7	52.12	56.62	58.6	93.12	Jan. 26, 1908	Mar. 13, 1908	
6	5 feet by 21 feet	19.7	150.4	6.09	49	1,360.1	75.7	65.3	70.0	72.0	93.12	Jan. 22, 1908	Mar. 18, 1908	
7	5 feet by 21 feet	17.4	177.1	6.05	49	1,267.7	72.8	63.1	67.6	69.6	93.12	Feb. 5, 1908	Mar. 24, 1908	
8	5 feet by 21 feet	17.4	218.4	6.90	52	796.5	65.2	57.2	61.7	63.7	93.12	Feb. 28, 1908	Mar. 31, 1908	
9	5 feet by 19 feet	15.9	230.7	9.00	52	1,654.4	62.0	53.6	58.3	60.3	93.12	Dec. 27, 1907	Feb. 13, 1908	
10	5 feet by 19 feet	15.9	195.0	7.20	48	1,396.8	72.7	59.12	63.62	65.62	93.12	Feb. 19, 1908	Apr. 6, 1908	
11	5 feet by 19 feet	15.9	120.9	4.50	39	877.9	80.6	70.12	74.62	76.62	93.12	Mar. 3, 1908	Apr. 16, 1908	
12	5 feet by 19 feet	15.9	124.5	4.78	39	850.2	80.8	70.12	74.62	76.62	93.12	Mar. 9, 1908	Apr. 22, 1908	
13	5 feet by 19 feet	15.9	154.6	5.83	44	812.4	79.4	66.12	70.62	72.62	93.12	Mar. 18, 1908	May 5, 1908	
14	5 feet by 19 feet	15.9	151.9	5.49	44	728.4	81.0	67.0	71.62	73.62	93.12	Mar. 27, 1908	May 22, 1908	
North abutment.	4 feet 3 inches by 21 feet.	26.5	92.2	4.26	27	438.8	87.9	73.63	78.13	80.13	93.12 97.58	Apr. 1, 1908	May 20, 1908	Top back wall, 97.58.
Totals		284.3	3,345.3	119.21	778	18,739.9								
		3,629.6												

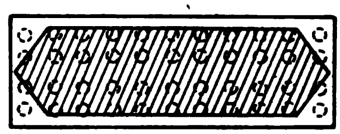
[a] Batter of all piers, 7.07 inches per foot.

[b] Class A, 1-1-4.

[c] Class B, 1-2-5.

Bridge No. 309.





SECTION THROUGH B-B.

Erection.

A bridge had been built at this point by the French, of which two spans, respectively 100 feet long and 200 feet long, were still standing. Although too light for heavy traffic, they were valuable for construction purposes. A temporary trestle was built from the north end of the channel span of this bridge, 18-foot centers for the new bridge, to a point beyond the north abutment. The south end of the 100-foot span was connected by track with the track in Bas Obispo cut. Over this track and bridge all material for construction of the piers was handled, and the trestle served in place of false work for the spans north of the truss, i. e., for eleven of the girder spans. In the construction of this trestle 9,391 linear feet of piles were used.

The first shipment of steel left the shops in Beaver Falls February 25, 1908, and the last March 20. They arrived in Colon March 25 and April 10, respectively. The girders were erected in the Gorgona shops of the Isthmian Canal Commission and shipped to the bridge site set up, ready for landing on the piers. The shop erection began March 27 and was finished by May 27. To place the 3 girder

spans south of the river channel and to erect the truss it was necessary to drive false work from the south end. This had been done by the time the first shipment arrived on the Isthmus, and on April 1 the erection of the truss span was begun. Work was pushed as rapidly as possible in order to get it in place before the rainy season should endanger the false work. This was accomplished when the span was swung April 14. The false work was then cut off at water level and removed. The girders for the spans north of the channel were landed with two cranes, one of which stood on the temporary trestle and one on the last completed span of the new bridge. Three, and part of the time, four riveting gangs were kept at work and practically all riveting was completed June 30, 1908. Painting of the bridge will be deferred until the next dry season, all rust being removed with wire brushes and a coat of oil having been applied immediately after erection.

Summary of cost.

Cost of placing concrete in piers, 3,518 cubic yards, labor and material, at $19.54 per cubic yard	$68, 753. 03
Cost of false work	6, 855. 67
Cost of steel and erection	83, 025. 04
Handling of miscellaneous material	2, 433. 40
Cost of hardware	2, 226. 41
Total cost	163, 293. 55

This total cost may be further divided as follows:

Substructure	$75, 608. 70
Superstructure	87, 684. 85
Total	163, 293. 55

FROM GAMBOA BRIDGE TO JUAN GRANDE (2 miles north of Gamboa).

As previously outlined, this section of the line was built because it opened up several important dumps for waste material from the Culebra Cut. A comparatively small force was kept at work on this section the entire year. Only small water openings were put in permanently, the larger valleys being left with an open temporary trestle. One temporary connection was built from the Gorgona gravel pit to land a steam shovel to work on large sidehill cut. The excavation of the remainder of this section was done by hand labor and task work was here used to good advantage. The located line here crosses several long valleys, and it is at these points the Canal Commission proposes to establish dumps, the material to be hauled out of Culebra Cut over the new Gamboa Bridge and dumped from trestles driven on the relocated line. There is dump ground available for 10,000,000 cubic yards. About 1 mile of trestle was driven in this section. This part of the line is now about complete, except the two or three large culverts, which will have to be put in next dry season.

PEDRO MIGUEL TO COROZAL.

After general operation was suspended in August there was no work done on this section, except at the Miraflores tunnel, and on the construction of two permanent arch culverts, one at the Pedro Miguel River and one at the Caimitillo River.

The Miraflores tunnel is laid out on a tangent 595 feet long, and has a grade throughout for drainage in both directions. Construction work on the tunnel has kept up constantly during the entire year, and, for the most part, work was carried on day and night. A connection track from the Panama Railroad to the north approach was complete in October, and this line is used for bringing material and supplies. A second connection track was more recently started, leading to the south approach, and this is now 90 per cent complete. The north approach was taken out at first by hand labor, and afterwards by steam shovel, and involved the moving of 10,000 cubic yards of earth and rock. The south approach was taken out by taskwork entirely, to the amount of 30,000 cubic yards. The excavation of the north end of the tunnel proper was begun in September. A drift or heading, about 6 by 8 feet, was carried through to coincide with the crown of the arch ring, and this drift was followed up by the excavation of the entire semicircle of the arch. Timbering was required throughout.

Attached is a photograph of the north portal of Miraflores tunnel, showing method of timbering. (Plate 182.)

A 5-piece arch ring, 12 by 12 feet and 12-foot by 14-inch posts were used. The distance between timber sets varies from 5-foot centers at the north end, where the material is rock, to 3-foot centers at the south end, which is in earth. The tunnel section provides lateral clearance of 7 feet 6 inches from center of track and vertical clearance of 22 feet above rail. The north end is in solid rock, although of a treacherous character, but for about 200 feet on the south side clay is encountered, which has a tendency to slide. Excavation is completed and timbers placed throughout 90 per cent of the length of the tunnel.

On all of the small cuts and at the tunnel portals so-called "taskwork" was used with much success. Under this system the laborer gets paid not by the hour or day, but by the number of Decauville cars of material excavated and placed in embankment—that is, the laborer is paid 10 cents gold for each car of material excavated from the cut and placed in the embankment. As these cars hold about one-half of a cubic yard, the labor cost for this class of excavation was about 20 cents gold per cubic yard. When the haul increased or harder material was encountered, extra men were put on, paid by the railroad company, and this would tend to increase the general labor cost per cubic yard for that particular piece of work, but the average cost per cubic yard for taskwork is about 30 cents. It is at this taskwork that the West Indian laborer is most proficient. The question of supervision solves itself. The usual bossing required in a gang hired by the hour is not necessary, and it is not difficult for one, on going over the line, to determine which gangs are working under the task system.

A 20 × 24 reenforced concrete arch culvert was put in at the Caimitillo River about 1,000 feet north of Miraflores, and one of similar size and design was put in at the Pedro Miguel River, opposite Pedro Miguel yard. Work was commenced on these in February and both culverts were finished by the first of June.

The following is a summary of the cost of these two structures:

Caimitillo River culvert.

Width	feet..	20
Height	do....	24
Length:		
Main arch	do....	117
Wing walls	do....	45
Excavation of site:		
4,520 cubic yards of earth, at $1.09		$4,923.05
Placing concrete (3,440 cubic yards):		
Labor, at $3 cubic yard		11,380.70
Material, at $5.85 cubic yard		20,124.60
Hardware cost		1,483.75
Total		37,912.10
Total cost of concrete placed, per cubic yard		10.59

Pedro Miguel culvert.

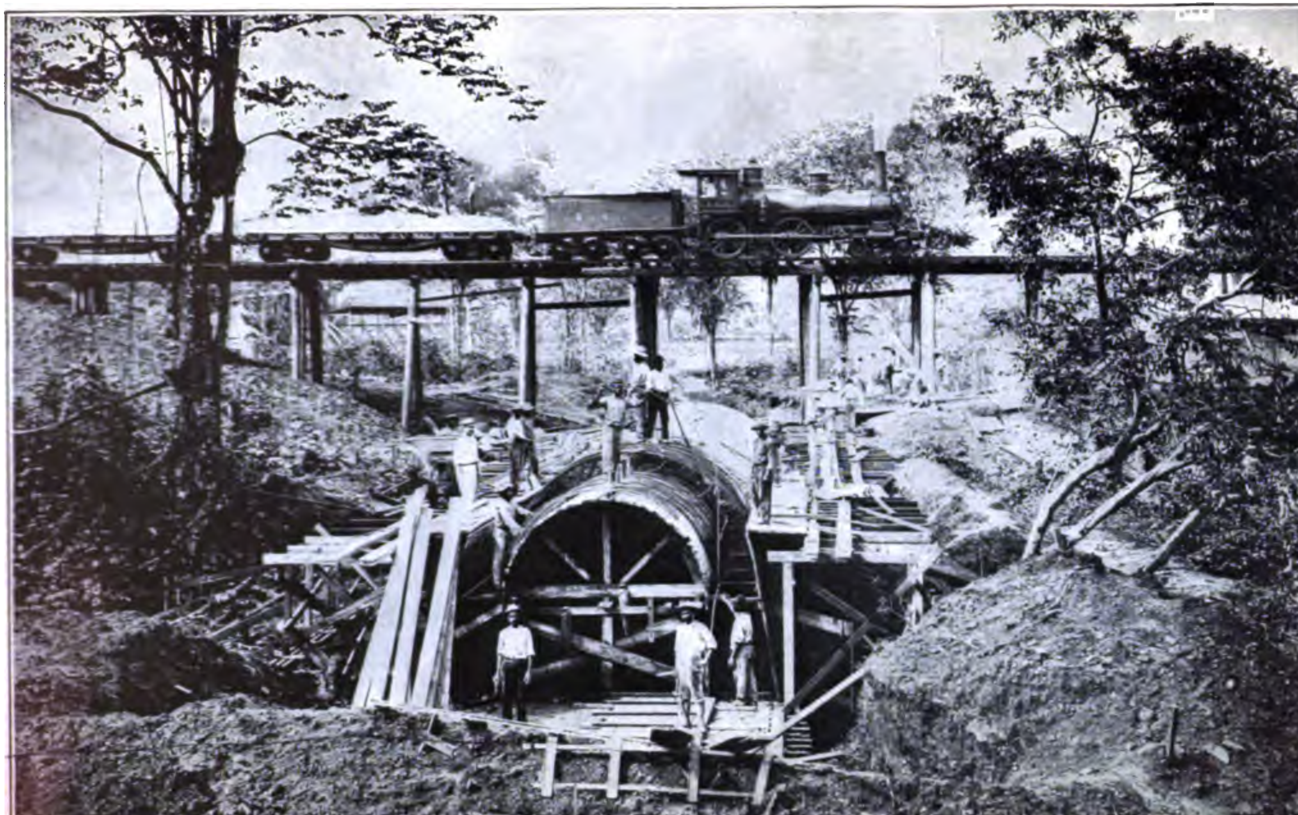
Width	feet..	20
Height	do....	24
Length:		
Main arch	do....	102
Wing walls	do....	44
Excavation of site:		
920 cubic yards, at $3.61 cubic yard		$3,432.30
Placing concrete (2,665 cubic yards):		
Labor, at $3.58 cubic yard		9,561.20
Material		15,036.94
Hardware cost		196.95
Total		28,227.39
Total cost per cubic yard of concrete placed		10.52

A change of alignment between Miraflores and Panama was made necessary during the year, due to the Canal Commission changing the location of the locks from La Boca to Miraflores. This change allowed us to drop down to the present grade of the Panama Railroad at Bridge No. 62, and will save the construction of a relocated line from the Cardenas River to La Boca Junction, a distance of 2.5 miles, at an estimated saving in cost of $200,000.

RELOCATED PANAMA RAILROAD LINE UNDER CONSTRUCTION, SOUTH OF GATUN.

MAKING EMBANKMENT IN THREE DECKS AT GATUN.

PLATE 177.



BUILDING A 10 BY 10 ARCH CULVERT AT GATUN.

GAMBOA BRIDGE SITE AFTER COMPLETION OF TRESTLE CONNECTING WITH OLD FRENCH BRIDGE.

GAMBOA BRIDGE, SHOWING SOUTH ABUTMENT, FIRST TWO PIERS, AND COFFERDAM FOR THIRD PIER.

PLATE 180.

GAMBOA BRIDGE, LOOKING SOUTH.

GAMBOA BRIDGE, PLACING LAST MEMBER OF TOP CHORD, CHANNEL SPAN.

NORTH PORTAL OF MIRAFLORES TUNNEL, SHOWING METHOD OF TIMBERING.

APPENDIX H.

APPENDIX H.

CONSOLIDATED STATEMENT OF EXPENDITURES FROM INCEPTION OF THE CANAL WORK TO JUNE 30, 1908.

	From inception to June 30, 1907.	From July 1, 1907, to June 30, 1908.	From inception to June 30, 1908.
Total department of civil administration	$1,442,386.62	$704,610.15	$2,146,996.77
Total department of sanitation	4,615,698.76	2,310,212.01	6,925,910.77
Total department of construction and engineering	13,423,434.81	16,680,660.46	30,104,095.27
Total municipal improvements	4,275,794.46	1,494,956.41	5,770,750.87
Total plant	19,415,093.89	11,684,215.15	31,099,309.04
Grand total	43,172,408.54	32,874,654.18	76,047,062.72

NOTE.—The amounts for the period "from inception to June 30, 1907," are changed from month to month by the addition of amounts paid for material expended on work prior to June 30, 1907, but not taken into account until after July 1, 1907.

Details of expenditures to "construction and engineering" and "plant."

	Kind of work.	From inception to June 30, 1907.			From July 1, 1907, to June 30, 1908.			From inception to June 30, 1908.		
		Expenditures.	Output.	Cost per cubic yard.	Expenditures.	Output.	Cost per cubic yard.	Expenditures.	Output.	Cost per cubic yard.
CONSTRUCTION AND ENGINEERING.			Cu. yds.	Cents.		Cu. yds.	Cents.		Cu. yds.	Cents.
Colon division	Dry excavation				$286,106.96	536,959	53.28	$286,106.96	536,959	53.28
Chagres division	do				1,425,821.21	1,774,124	80.37	1,425,821.21	1,774,124	80.37
Culebra division	do	$11,861,209.16	8,076,327	146.86	11,043,996.68	12,065,138	91.54	22,905,205.84	20,141,465	113.72
La Boca division	do				49,299.83	55,490	88.84	49,299.83	55,490	88.84
Colon division	Wet excavation	410,163.15	2,060,566	19.90	658,721.31	5,087,623	12.95	1,068,884.46	7,148,189	14.95
La Boca division	do	410,049.64	2,317,482	17.69	595,368.25	5,273,369	11.29	1,005,417.89	7,590,851	13.25
Chagres division	do				9,798.40			9,798.40		
Gatun dam and spillway	Dry excavation	5,057.31	3,832	131.98	497,049.14	938,901	52.94	502,106.45	942,733	53.26
Do.	Wet excavation				17,678.05	38,425	46.01	17,678.05	38,425	46.01
Do.	Miscellaneous construction	172,151.52			313,567.27			485,718.79		
Gatun locks	Dry excavation	339,294.16	489,663	69.29	802,136.13	1,769,115	45.34	1,141,430.29	2,258,778	50.53
La Boca dam and spillway	do	1,917.56	10,792	17.77	35,995.00	28,055	128.30	37,912.56	38,847	97.59
Do.	Miscellaneous construction	117,179.75			181,157.27			298,337.02		

La Boca locks	Dry excavation	1,303.89	538	242.36	111,570.15	38,848	287.20	112,874.04	39,386	286.58
Do.	Miscellaneous construction	61,899.83			89,517.44			151,417.27		
Pedro Miguel dam	do.	1,539.32			5,655.32			7,194.64		
Pedro Miguel locks	Dry excavation				30,190.95	13,228	228.24	30,190.95	13,228	228.24
Do.	Miscellaneous construction	41,669.52			75,328.12			116,997.64		
Miraflores dam and spillway	Dry excavation				19,681.84	13,986	140.73	19,681.84	13,986	140.73
Do.	Miscellaneous construction				21,009.07			21,009.07		
Miraflores locks	Dry excavation				411,012.07	346,114	118.75	411,012.07	346,114	118.75

RECAPITULATION.

		Cu. yds.	*Cents.*		*Cu. yds.*	*Cents.*		*Cu. yds.*	*Cents.*
Dry excavation	$12,206,782.08	8,581,152	142.27	$14,712,859.96	17,579,958	83.69	$26,921,642.04	26,161,110	102.91
Wet excavation	820,212.79	4,378,048	18.73	1,281,566.01	10,399,417	12.32	2,101,778.80	14,777,465	14.22
Miscellaneous construction	394,439.94			686,234.49			1,080,674.43		
Total department of construction and engineering	13,423,434.81	12,959,200		16,680,660.46	27,979,375		30,104,095.27	40,938,575	

PLANT.

	Expenditures from inception to June 30, 1907.	Expenditures from July 1, 1907, to June 30, 1908.	Expenditures from inception to June 30, 1908.
Panama R. R., second main track	$898,663.16	$118,670.12	$1,017,333.28
Relocation of Panama R. R.	150,381.13	1,436,234.17	[a] 1,586,615.30
Rolling stock	5,178,923.02	1,805,833.45	6,984,756.47
Excavating machinery	1,822,171.37	1,130,218.49	2,952,389.86
Floating equipment	1,677,643.40	2,798,916.89	4,476,560.29
Shop and other machinery and tools	810,216.01	647,550.14	1,457,766.15
Rails, fastenings, and ties	990,574.59	1,069,108.46	2,059,683.05
Construction of electric-light plants	82,602.25	90,827.32	173,429.57
New buildings	7,342,200.27	2,346,135.99	9,688,336.26
New buildings, department of civil administration		49,019.81	49,019.81
New buildings, department of sanitation		86,733.08	86,733.08
Docks and wharves	402,619.07	99,531.61	502,150.68
Lands purchased	59,099.62	333.73	59,433.35
Corral equipment		5,101.89	5,101.89
Total plant	19,415,093.89	11,684,215.15	31,099,309.04

[a] Embraces all expenditures for New Panama Railroad.

A. B. NICHOLS, *Office Engineer.*

CULEBRA, CANAL ZONE, *August 8, 1908.*

Statements of Cost, Exclusive of Civil Administration, Sanitation, and Municipal Improvement.

EXCAVATION, LOCK AND DAM CONSTRUCTION, MONTHLY TOTALS OF WORK ACCOMPLISHED.

	eneral items.		
	General administration.[c]		17
	15	16	
From work			
July		$1,086.86	
August		4,704.47	
Septem		3,854.17	
		9,645.50	
Octob		1,923.65	
Novem		3,063.66	
Decem		5,250.94	
		19,883.75	
Janua		6,840.92	
Febru		5,331.23	
March		4,218.43	
		36,274.33	
April		4,229.10	
May		3,834.12	
June		4,708.19	
		49,045.74	

From work			
July			
Augus		$1,909.84	
Septe		7,079.33	
		8,989.17	
Octob		7,694.60	
Nover		9,190.98	
Decem		23,817.82	
		49,692.57	
Janua		32,962.46	
Febru		33,539.86	
March		29,726.81	
		145,921.70	
April		34,145.29	
May		38,111.92	
June		42,410.63	
		260,589.54	

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395.48	$199,467.57	
565,863.06		......
....	74,993.52	......
....	194,366.09	......
....	160,347.04	......
....	429,706.65	......
....	153,892.55	......
....	111,324.02	......
....	184,923.89	......
....	879,847.11	......
....	202,160.24	......
....	185,437.79	......
....	145,050.47	......
....	1,412,495.61	......
....	153,459.80	......
....	183,609.38	......
....	212,653.95	$84,68
....	1,962,218.74	84,68

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....	$1,150.12	......
....	1,212.76	......
....	1,892.57	......
....	4,255.45	......
....	1,522.97	......
....	1,486.08	......
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neral items.[b]		
neral administration.[c]		17
15	16	Leve
....	$19,730.10	....
....	4,032.01	....
....	10,562.08	....
....	7,662.59	....
....	22,256.68	....
....	6,680.28	....
....	5,219.76	....
....	9,957.41	....
....	44,114.13	....
....	....	....
....	11,617.88	....
....	9,951.90	....
....	65,683.41	....
....	12,677.11	....
....	15,653.90	....
....	15,239.43	....
....	109,253.85	....

....	$19,721.97	....
....	2,687.98	....
....	8,099.33	....
....	8,683.79	....
....	19,471.10	....
....	11,133.82	....
....	6,959.72	....
....	10,051.41	....
....	47,616.05	....
....	....	....
....	9,305.61	....
....	8,225.46	....
....	65,147.12	....
....	9,041.43	$1,66
....	11,610.00	3,34
....	13,238.92	....
....	99,037.47	5,00

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eral administration.[c]		17	
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	382.62		
	237.48		
	74.05		
	1,730.68		

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al administration.[c]		17
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....	$1,539.76	....
....	5,309.43	....
....	6,960.79	....
....	13,809.98	....
....	4,992.65	....
....	3,526.57	....
....	1,330.98	....
....	23,660.18	....
....	12,421.34	....
....	10,446.93	....
....	9,251.94	....
....	55,780.39	....
....	10,134.70	....
....	11,277.25	....
....	10,682.59	....
....	87,874.93	....

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APPENDIX I.

REPORT OF W. G. TUBBY, CHIEF OF THE DIVISION OF MATERIAL AND SUPPLIES.

CRISTOBAL, CANAL ZONE, *August 1, 1908.*

SIR: I have the honor to submit herewith the annual report of the division of material and supplies, Isthmian Canal Commission, Canal Zone, for the fiscal year July 1, 1907, to June 30, 1908.

The division of material and supplies, the head of which reports direct to the chairman and chief engineer, is charged with the purchase and handling of all material and equipment needed in connection with the construction of the canal on the Isthmus. The diversity of the work necessitates the purchase and use of a very great variety of equipment, material, and supplies, including stock for repairs. All departments on the Isthmus rely upon this division to supply their needs, and every effort is made to anticipate requirements and keep a complete stock by frequent purchases in the United States. The purchases are based on estimates submitted by the various divisions or gauged by the rate of consumption of stock on hand at the several storehouses along the line of the canal. There are also included in the duties of this division the care and maintenance of the local transportation, the operation of the printing plant that does the printing for the commission, and a shop for the repairing of all typewriters on the Isthmus in use by the United States Government.

CLASS OF SUPPLIES HANDLED.

It has been necessary to purchase rails and other track material, locomotives, cars, steam shovels, cranes, pile drivers, drills, earth spreaders, earth unloaders, and other equipment for the physical work of excavation and the disposition of the excavated material; lumber, roofing, hardware, plumbing, and all classes of building material for the construction, repair, and maintenance of quarters for all classes of employees; shops, storehouses, oil houses, hospitals, hotels, laborers' kitchens, penitentiaries, jails, post-offices, office buildings, clubhouses, cold-storage and ice plants, laundries, bakeries, etc.; equipment, appliances, medicines, drugs, etc., for hospitals, dispensaries, and sick camps; machinery, tools, and supplies for shops, planing mills, foundries, roundhouses, etc.; equipment and supplies for the police and fire departments; furniture, dishes, and other equipment for all classes of employees' quarters, hotels, and laborers' kitchens; track material and tools for the construction, repair, and maintenance of tracks; animals, vehicles, forage, and corral supplies for local transportation; stone crushers, rollers, cement, sewer and water pipe, brick, pumps, boilers, engines, and other material for the use of

the division of municipal engineering; dredges, tugs, lighters, barge launches, and other floating equipment for the marine work, and num berless other items used in connection with the operation, repai and maintenance of the equipment named, together with standar materials and supplies for stock at the various storehouses, for th shops, and for the use of all departments on the Isthmus. The stand ard materials and supplies consist of repair parts for locomotive steam shovels, cars, drills, and other equipment and machinery small tools for the shops; iron, steel, builders' hardware, plumbin material, furniture, marine equipment, stationery and printed form and a great number of other articles that are constantly in use b all branches of the work.

We aim to limit our supply of standard material to approximatel six months' requirements, this by reason of the length of time requires from date of requisition to advertise, award contracts, shi the material from the States and receive same on the Isthmus. Ever department on the Isthmus is dependent upon this division for it supplies, and we carry at each of our substores the class of materi and kind of supplies that are needed by the departments operat ing in that vicinity, and the material situation is canvassed con tinually with all departments with a view to keeping in touc with their requirements. For convenience in placing stock requis tions storekeepers also keep a book record of stock. These stoc books show the quantities on hand at the beginning of the montl the quantities ordered each month, and the quantities received an used during the month. By means of this record the storekeeper are enabled to keep posted as to the rate of consumption of variou materials from month to month, and their stock orders are base upon the rate of consumption as shown on their stock books.

REQUISITIONS FOR NEW MATERIAL.

For all material and supplies needed that are not on hand o obtainable under existing contracts, requisitions are submitte through this division to the general purchasing officer of the commi sion, whose headquarters are at Washington. All purchase requis tions are made through this division, either by the division or depart ment requiring the material or the general office of this division, fro information obtained by means of local requisitions or estimates o the requirements of certain divisions submitted from time to time A separate series of purchase requisition numbers is used for ea division of the commission. For instance, all requisitions for th department of engineering and construction, sanitary department, o any other department bear a number from a series used only by th department for whom the requisition is made, a suffix letter bein used before the number on each requisition to indicate the series t which the requisition belongs. Requisitions are numbered consecu tively, beginning at 1, from the commencement of the fiscal year and copies of all requisitions made are filed in the office of the chie of the division of material and supplies. The different departments for whom United States requisitions are made are as follows: Engi neering and construction, sanitary, civil administration, disburse ments, and material and supplies, the last-named department makin all requisitions for material for general stock.

When a requisition asking for the purchase of any material is received, it is first checked to ascertain whether the articles required, or a portion of them, can not be supplied from stock on hand or on order. All purchase requisitions bear complete information as to the quantities wanted, on hand and on order, with specifications, blueprints, or sketches. The requisition also shows when the material is required, the marks to be placed on the packages, and the date that delivery is desired. All items are described fully, so that the purchasing officer can intelligently advertise for bids.

When contracts for material ordered have been awarded to the successful bidder, the general purchasing officer sends two copies of the award to the division of material and supplies for its information, and in turn this division transmits one copy to the officer originating the requisition. The general purchasing officer also sends copies of all correspondence regarding the delivery of the material by the contractor, and in this manner our requisition files are made to show the complete status of any requisition. The awards show to whom contract has been awarded, price at which goods are to be furnished, date of delivery, and all information essential to enable this division to keep check on delivery and, when necessary, take up with the general purchasing officer the matter of material not being received by the time specified in the contract.

RECEIPT, INSPECTION, AND DISPOSITION OF SUPPLIES.

All material shipped to the Isthmus, prior to shipment from the States, is inspected by the government inspectors, who report direct to the general purchasing officer. A second inspection is also made on the Isthmus. Material and supplies are received at Colon and Cristobal on the Atlantic side, and at La Boca on the Pacific side. They are transported to the Isthmus by various steamship lines and chartered tramp vessels of different classes, as well as by the Panama Railroad Steamship Line which is operated by the Government of the United States. All material received is loaded onto cars direct from the ships or from the docks, and forwarded to fill orders on hand, or placed in stock at the storehouses or yards at different points. Locomotives, cars, steam shovels, and other heavy machinery and equipment received knocked down are shipped direct from the docks to the shops to be set up ready for service. The greater portion of the material received is sent for disposition to the general storehouse, located about 1 mile from Cristobal, at which storehouse the bulk of the material and supplies used on the Isthmus is received, inspected, classified, and stored or shipped direct to the points where they are required. It is from this general storehouse that each of the 8 division stores on the Isthmus receive their supplies from time to time. The general storehouse, including platform, is 700 feet long by 150 feet wide and is two stories in height. The oil and paint house adjacent to this store is 250 feet long by 57 feet wide, and in this building all inflammable material is stored. There are also 3 other buildings of smaller size at this point used for the storage of cement, fire clay, etc. The yard in connection with the general store has a capacity of 365 cars. The only cargoes received on the Pacific side of the Isthmus are shipments of lumber and forage from the territory contiguous to Puget Sound, which are either shipped

out directly to fill orders or are stored in the lumber yard at La Bo on the Pacific side, at Culebra where the planing mill is located, or a Cristobal on the Atlantic side.

With each shipment we receive copies of the dealers' invoices, wi packing lists and bills of lading, and as all packages are marked w the requisition number and name of the party and division orderin and the invoices and bills of lading bear the same marks, we are at to inform ourselves, immediately upon receiving the ship's paper what cargo she carries, and make prompt disposition. For all mate rial and supplies ordered for divisions other than the division of mat rials and supplies we aim, where the bulk of the freight will warra to have shipments made direct from the dock to the consignee, a thereby save the expense of rehandling at Mount Hope.

For material or equipment, such as cars, locomotives, stea shovels, and machinery, shipped direct from the dock to originatin officer, two copies of the inspection call are forwarded to the head the department of that officer, with request that the material b inspected. For all material sent to the general store, the inspecti calls are forwarded to the storekeeper at that place. Inspection the Isthmus is principally for the purpose of ascertaining damages a shortages, as the inspection in the United States is supposed to co the relation of the material to the specifications. If, however, ma rial is received that does not clearly comply with the specificati even though it has passed inspection in the United States, the mate is held and the matter brought to the attention of the general p chasing officer for his consideration. No dealers' invoices are pas without a signed inspection call, or certificate of inspection, from interested division. Inspections are made at the earliest poss moment, so that there will be no delay in passing the invoice f voucher. The division of material and supplies has inspectors a checkers at the general store and at the dock, who pass upon material received, while the inspection at other points for mater such as steam shovels, locomotives, cars, machinery, and other eq ment shipped direct, is made by the head of the department receiv the material or some one authorized by him to perform that functi

CARE AND CUSTODY OF MATERIAL AND SUPPLIES.

After the material for stock has been inspected, it is placed in storehouses and drawn upon as required to fill orders. The gen storehouse is subdivided into sections, each containing a certain of material. The goods received there are placed in their respe sections as soon as they are unloaded and inspected. The iron steel are placed in racks, the paints and oils in oil houses. Mate that is affected by moisture is placed under shelter. Lumb assorted and placed in neat piles capable of shedding water; an fact, all classes of material and supplies are stored safely, conv iently, and systematically.

The issue of material and supplies is made by competent storeh men, under the immediate supervision of the storekeeper or his ass ants. The storehouses and surroundings are kept clean and from inflammable materials. Fire protection is provided for buildings in this division and watchmen are kept on duty day night to prevent loss by theft or fire.

ISSUE AND TRANSFER OF MATERIAL AND SUPPLIES.

Material and supplies are issued from each of the nine storehouses, ncluding the general store, to supply the needs of the territory contiguous to that store. No material is issued, except upon the receipt of properly approved requisitions, for which purpose three forms are used. All supplies issued direct from a storehouse to the mechanical department at that point are delivered upon the receipt of a foreman's order. These orders are consolidated daily into one requisition which, after being approved by the master mechanic and the superintendent of motive power, is forwarded to the general office of the division of material and supplies. All supplies that require transshipment from one storehouse to another place in the Canal Zone are ordered on a combined requisition and shipment order. This form is used by all divisions and, when the material is urgently required and can be supplied from a local storehouse, the requisition is sent direct to the local storehouse for immediate action, while a copy is sent to this office for file. When the local storekeeper has made shipment or delivery of the material called for, he forwards the accomplished requisition to this office, showing in the spaces provided for that purpose the details of the shipment. The use of this combined requisition and shipping form saves a great deal of the clerical work that was done before this form was adopted, as the "shipment order" was then written on a separate form. Requisitions for stationery and printing are made on a form provided specially for that purpose, and are forwarded to the stationer and printer at Panama for action.

For material shipped direct from a storehouse to the mechanical department, the receipted local requisition is used as an expenditure voucher, while for material shipped from any of the stores to parties along the line, store invoices are made at once, and the receipted store invoice used as a voucher. For material shipped by the stationer and printer, invoices are made direct by him and, upon acceptance, are forwarded to this office as expenditure vouchers. These receipted local requisitions and store invoices are used to support our expenditure accounts, which are sent each month to the disbursing officer. Any material that is required by a substore for stock is ordered in the regular manner by the storekeeper, on the combined requisition and shipment order above referred to, but the issue is covered by a transfer invoice, while the invoice is not used as an expenditure voucher, but simply as a receipt for material shipped. For each shipment a shipment notice is sent to the consignee to notify him when the shipment may be expected, which shows details of the material shipped.

When any division has material that can be spared for purposes other than work under its jurisdiction, and it is desired for stock, a requisition is made by the division of material and supplies in the regular manner, and the stock is transferred to this division on a transfer invoice form. For material that is issued to another division, but still remains in the custody of the division—as, for instance, live stock and corral equipment—a memorandum receipt is obtained from the division receiving the animals and equipment, and this receipt is filed as evidence of the disposition of the material.

MANUFACTURING ORDERS.

For material that can be manufactured on the Isthmus to bet advantage than it can be purchased in the States, or where the urge precludes the delay incident to purchase in the States, or for re work to be done, a manufacturing order is issued on the departm that can best perform the work. In case the material is made stock purposes, and goes into any one of our storehouses for is the cost of the entire order is invoiced against this division on transfer invoice. In case of repair work, the cost is invoiced di against the division requesting that the repairs be made. Mate manufactured for stock is taken into my accounts and issued the sa as material purchased.

ACCOUNTING FOR MATERIAL AND SUPPLIES ISSUED.

This division keeps both physical and financial record of mate received and issued or transferred. It is debited with all mate purchased from the United States for all departments; for all ma rial purchased locally, and for all material manufactured for st Purchase invoices are accepted by this division as soon as we rece the signed inspection call, and are numbered consecutively, comme ing at 1, a new series being commenced at the beginning of the fis year. The purchase requisitions accepted by each sailing date listed on a form known as "Abstract of certified bills" and forward with the abstract to the disbursing officer at Washington thro the disbursing officer on the Isthmus. The amounts of the certi bills are debited to my account. Material purchased locally is a debited to this division. Material manufactured on the Isthmus charged to this division on transfer invoices, and debited to this di sion when the receipted transfer invoice is forwarded to the disbu ing officer on the Isthmus. Our account receives credit for mater issued to other departments. For material sold to outside partie individuals, and for damaged or destroyed material dropped authority of the board of survey and appraisal, we likewise rece credit.

For material received, a stock record is kept on stock sheets, at t storehouses. These stock sheets show full description of the mater the quantity received, from whom received, and the price. At t main office of the division stock sheets are kept which cover material received on the Isthmus. Any issues are credited to t stock cards and stock sheets, the local storekeeper making the fir record of the issues on his stock cards and then forwarding the pa to this office, where record is also made. This part of the work carefully watched and records at outside points carefully inspect periodically to see that they are carefully and accurately ke Sales to outside parties are credited in the same manner on the st records, these sales consisting principally of material or supplies s to the different municipalities in the Zone and to the Panama Ra road Company. Material disposed of by action of the board survey and appraisal is dropped upon receipt of proper authori from the board and a copy of the proceedings sent to the disburs officer to support the credit so taken.

All receipted local requisitions, and all accomplished store invoices are abstracted at the close of each month, in the main office of the division of material and supplies, and forwarded to the disbursing officer. The abstract shows the store invoice or local requisition number, against whom charged, and the specific account number for which the material was used.

INVENTORY AND PROPERTY RETURNS.

A full and complete inventory of all unexpended material in the custody of this division is taken at the close of every fiscal year. Inventories are carefully taken as to description and quantities, and the completed inventory forwarded to the disbursing officer. Inventory quantities are compared with the stock balances at all stores as shown by the stock-card record, with a view to discovering discrepancies and reasons therefor. Property returns for all unexpendable property are rendered at the close of each quarter. These returns are forwarded to the disbursing officer for check. No property that has become worthless from any cause, or that has become worn out through service, or that has been damaged through no fault of the responsible or accountable officer, is disposed of without authority from the board of survey and appraisal, whose duties are to grant relief for property lost, destroyed, or rendered unserviceable through no fault or neglect of any employee of the division, and to grant authority for the disposition of French equipment, such as cars, boilers, engines, tools, and mechanism and parts of same, when required for use by any division of the commission; and all old French material to be disposed of by sale, also, has to be condemned and appraised by the board of survey and appraisal.

Sales are made of certain scrap and unusable materials after condemnation, appraisal, and advertisement, in the prescribed manner. A large quantity of old French material that was absolutely worthless for any other use by the commission has been scrapped and used in our cast iron and brass foundries; while a large amount of old French material, likewise worthless, but unfit for use in the foundries, has been disposed of by sale to outside parties. When an offer is received for such material, request is made on the chairman of the board of survey and appraisal for the board to pass upon it; and if, after investigation, it is determined that the material can not be used by the commission in connection with the work, it is condemned, appraised, a minimum price fixed, and authority is given to dispose of it to the highest bidder after due advertisement. Unserviceable live stock is also sold after condemnation, appraisal, and due advertisement.

STOREHOUSES AND PLACES OF STORAGE.

The following storehouses are under the jurisdiction of the division of material and supplies: General storehouse at Mount Hope; storehouse at the dry dock shops, Cristobal; storehouse at Gorgona; storehouse and powder magazine at Bas Obispo; storehouse at Empire; storehouse, lumber yard, and powder magazine at Culebra; storehouse at Paraiso; storehouse at Pedro Miguel; storehouse at Ancon;

storehouse and lumber yard at La Boca; stationery store and prin plant in the administration building, Panama; storage at dock Cristobal, for piles, rails, and ties, besides certain old French buildi containing French stock at different points. Each storehouse s plies material within certain jurisdictions, as follows:

The general store at Mount Hope furnishes supplies to all substor All departments on the Isthmus procure their supplies from either t general store or the substores.

The store at the dry dock, Cristobal, supplies the needs of the d dock shops and the floating equipment on the Atlantic side of t Isthmus.

The store at Gorgona supplies the district between Gatun a Gorgona and the shops at Gorgona, and is one of the most importa stores on the Isthmus. At Gorgona are located large mechan shops consisting of machine, boiler, blacksmith, erecting, patte and car shops, brass and iron foundries, which employ about 1,0 men.

Bas Obispo store supplies the needs of the engineering depa ment at the north end of Culebra Cut. Bas Obispo store also iss dynamite from the large storage magazines to the service magazin on the work.

Empire store supplies the district between Bas Obispo and Parai and attends to the wants of all departments in that district. furnishes the entire Culebra division with supplies for steam shove locomotives, cars, track material, repairs for drills, explosives f blasting, material and supplies for the air compressor plants, a pipe and fittings for air lines; material and supplies for Las Casca car repairs and roundhouse use; supplies for the master build municipal engineer, sanitary department, the land transportati etc.

Culebra store supplies the immediate needs of all departments Culebra. It also has charge of the lumber yard and powder ma zine near Culebra.

Paraiso store supplies the needs at the south end of the Culeb cut and the shops at that place, as well as those at Pedro Miguel.

Ancon store supplies the needs of the large corral at Ancon, a other departments in that locality. This store carries the bulk stock for repairs to wagons, carts, carriages, and other vehicl harness, and other corral equipment.

La Boca store supplies the marine shops and floating equipme at La Boca and carries a stock of lumber for use by all departme on the Isthmus.

The stationery and printing plant in the administration buildi in Panama supplies all the stationery and printing required by t commission on the Isthmus. A complete stock of standard st tionery is carried at all times, as well as special supplies for the en neering department. The printing plant prints the forms requir on the Isthmus, as well as special blank books, meal tickets, et There is a stamp factory in connection with the printing plant, wh rubber stamps are made as required. During the past year t printing plant has been running to its full capacity, 14 presses hav been kept busy. There is also a bookbinding department in t printing office, where a large number of books are bound. Abo

30,513,497 pieces of printed matter have been turned out during the past year, valued at $38,513.10. Stationery and engineers' supplies have been issued amounting in value to approximately $32,758. The printing plant consists of an up-to-date and well-equipped printing establishment, capable of turning out all printed work required for forms, letter heads, and other stationery, as well as binding books, etc. The Canal Record, an 8-page paper, published weekly under the authority and supervision of the Isthmian Canal Commission, is printed here. This paper is issued, one copy each, free of charge, to all white employees of the commission, approximately 12,000 copies being printed of each issue. About 516,000 copies of the Canal Record have been published during the past fiscal year.

At dock 14, Cristobal, is carried a stock of piles, ties, and rail. This material represents only that part of a vessel's cargo that can not be immediately shipped from the dock as unloaded, but is stored for convenience at this point until required. This material is handled economically with the cantilever crane installed at this dock.

Exclusive of the above places of storage, there are a number of old French storehouses at different points that serve for storage of a miscellaneous lot of French equipment and supplies that have been on hand since the time of French occupation and control. Considerable of this material is being used monthly.

LOCAL PURCHASES ON THE ISTHMUS.

Local purchases are made for certain materials and supplies which, as a rule, are not carried in stock, where it is necessary to procure an immediate supply, owing to the urgency of certain work. Occasions arise where work would be delayed for the want of material, the urgency of which would not allow of the regular routine of a purchase in the United States, making it imperative that the material be purchased in the local market. A great portion of the local purchases consist of subsistence supplies for engineering parties, the subsistence department, and for the hospitals. Subsistence supplies for the hospitals consist principally of fresh meats, vegetables, fruits, milk, eggs, and fish.

For material that is awarded under contract, regular advertisements are inserted in the local papers, specifying the articles required and necessary information for intelligent bidding by competitors. A definite date is set for the receiving of bids and the award is made to the lowest responsible bidder. For small quantities of material that can not be procured from the Panama Railroad commissaries no advertisement is inserted in the newspapers, but a proposal blank is sent to the principal local merchants, and sale is awarded to the lowest bidder as determined in the above manner. Local purchases from the Panama Railroad store and commissaries are covered by a regular award in the same manner as those made from outside firms.

Bills are rendered for local purchases and for any material that is taken into stock and issued by this division. Vouchers are made in this office on the prescribed forms and are forwarded to the disbursing officer for payment. For local purchases for the subsistence department, the vouchers are made by that department; for purchases

made for the hospitals, the vouchers are made by the sanitary dep- ment. No voucher is paid until a certificate of inspection is giv by the party receiving the material, and the same safeguards adopted by the disbursing officer on the Isthmus as are used by disbursing officer in the United States.

LOCAL TRANSPORTATION.

The local transportation system was placed under the jurisdict of this division by a resolution of the commission adopted Augu 1905. All nonexpendable material belonging to the system is carr on my property returns, and the property that is assigned to the u of another department is receipted for on memorandum recei Private animals owned by canal employees, and used by them private purposes, are cared for at our corrals, so far as the accom dations will admit, and regular bills are rendered monthly against owners for the cost of forage and stable care. Private animals own by employees and used by them in the discharge of their official du are cared for and foraged at the Government's expense, when prope approved requisitions are received to cover.

Corrals are located at 16 different points, and accommodate at present time about 185 horses and 447 mules, a total of 632 anim of which 536 are the property of this division. Of the balance, animals belong to the police department, 59 to private parties, 10 the Panama Railroad Company, and 1 to the fire department.

The corrals are in charge of competent foremen and are kept a clean and sanitary condition. The entire local transportation sy tem is in charge of a superintendent of local transportation, w exercises supervisory jurisdiction over the entire Isthmus and repor direct to the head of the division. The health of the animals is look after by two experienced veterinary surgeons, who make week inspections of all corrals and animals. All animals on the Isthm owned by the Government are branded and numbered with alum num tags in the ears. The vehicles are all marked so as to determ ownership to the Government, and the same care is taken of fora and corral supplies as is taken of any other stock in charge of t division.

GENERAL REMARKS.

The amount of material handled by the division of material ar supplies during the fiscal year 1907–8 has been much heavier tha during the previous year. During the fiscal year 1906–7 there w purchased and taken into our accounts material valued at approx mately \$9,500,000, and the disbursements amounted to \$9,000,00 while during the fiscal year 1907–8 we received material valued a \$11,607,094.63, and disbursed material valued at \$11,685,158.3 being \$78,063.70 more than value of the material received. T total value of receipts and disbursements handled by the divisi during the year 1907–8 were valued at \$4,792,252.36 more than th receipts and disbursements of the previous year. During the pa year the division received 72 full cargoes of material and part car- goes from 250 ships, while during the fiscal year 1906–7 there were received 37 full cargoes and part cargoes from 150 ships.

Value of material received and disbursed during the fiscal year 1907–8 is shown as follows:

Value of material received.

Received from the United States on United States bills	$10, 507, 016. 07
United States department bills	30, 969. 18
Local purchases	17, 210. 41
Purchased from the Panama Railroad	390, 799. 77
Manufactured for stock	493, 556. 30
Returned to stock	167, 542. 90
	11, 607, 094. 63

Value of material issued.

Issued to all departments:	
New stock	$11, 502, 263. 77
French stock	182, 894. 56
	11, 685, 158. 33

As shown by the above statement, the amount of French material used or disposed of during the past year was valued at $182,894.56. In this amount is included all scrap brass, copper, and cast iron used in the foundries at Gorgona shops.

During the past year the rebuilding of the large general storehouse at Mount Hope, which was partly destroyed by fire on April 1, 1907, was completed and restocked. New storehouses have been built at Bas Obispo, Empire, Culebra, and Paraiso, in addition to new oil houses at Mount Hope, Gorgona, Empire, and Bas Obispo, all of which enable this division to better care for and promptly and economically handle the large increase in business. During the past year there has also been authorized the construction of two storage magazines for dynamite, of 300 tons capacity, two magazines for storage of electric exploders, blasting caps, fuses, etc., and two watchmen's houses to be erected adjacent to same. One set of buildings is to be located in the Mindi Hills, about 7,500 feet from the Panama Railroad at Mindi, and the second set about 9,000 feet from the Gamboa Bridge, up the Chagres River. Great care has been taken in the selection of the sites for these buildings, so as to prevent loss of life and property in the event of accidental explosion. Track has been laid from the main line of the Panama Railroad to the site in the Mindi Hills, and work has commenced on the buildings at that place, which are to be constructed of concrete blocks. We have under consideration at the present time the construction of three new storehouses, one to be erected at the dry dock, Cristobal, one at the Gatun lock and dam site, and one at La Boca shops, the business of this division at those points having outgrown the capacity of the old French buildings now in use, and by putting up new buildings there will be gained the additional advantage of economy in labor through having the storehouses convenient to the shops.

I annex the following statements, showing the principal items of material handled by this division since the inception of the canal work, and especially during the fiscal year 1907–8; animals and vehicles in charge of this division; amount of pay rolls for the past fiscal year, and expenditures for account of sick leave and vacation; organization of the division of material and supplies:

No. 1. **Statement of important items of material received from July 1, 1907, to June 30, 1908.**

No. 2. **Important items of material received from inception of canal work, 1904, to June 30, 1908.**

No. 3. Statement of material due on United States requisitions, July 1, 1908.
No. 4. Statement of kind and number of vehicles in use on the Isthmus, cared f[illegible] the division of material and supplies.
No. 5. Statement showing live stock stabled and foraged by the division of mat[illegible] and supplies.
No. 6. Statement of amounts of payrolls of the division of material and supplies fr[illegible] July 1, 1907, to June 30, 1908.
No. 7. Statement of expenditures for account of sick leave and vacation of employ[illegible] of the division of material and supplies, from July 1, 1907, to June 30, 1[illegible]
No. 8. Organization of the division of material and supplies, June 30, 1908.

No. 1.—*Important items of material received by the division of material and supp[illegible] from July 1, 1907, to June 30, 1908.*

Article.	Quantity.	Value.
Steam shovels	38	$403,69[illegible]
Cars	800	900,4[illegible]
Unloaders	10	52,[illegible]
Ballast plows	6	6,4[illegible]
Spreaders	10	66,0[illegible]
Cranes	9	81,[illegible]
Dredges	8	1,061,[illegible]
Tug boats	5	299,0[illegible]
Steel barges	12	249,9[illegible]
Air compressor	1	4,0[illegible]
Rock drills	172	54,7[illegible]
Rock channelers	13	32,3[illegible]
Track bolts ... pounds	508,000	13,4[illegible]
Track spikes ... do	1,684,000	34,7[illegible]
Angle bars ... do	119,150	44,71[illegible]
Tie plates	470,000	56,41[illegible]
Rail braces	5,000	4[illegible]
15-foot split switches	481	11,3[illegible]
Switch points	410	4,6[illegible]
Frogs	628	12,82[illegible]
Switch stands	880	7,8[illegible]
Railway water tanks	3	1,54[illegible]
Oil fuel tanks	15	14,21[illegible]
Launches	2	2,[illegible]
Concrete mixers	4	3,6[illegible]
Road rollers	1	2,5[illegible]
Motor cars	3	2,8[illegible]
Air-compressor plant (La Boca)	1	34,634[illegible]
Material-handling plant (Gatun)	1	293,614[illegible]
15-ton rock crusher (La Boca)	1	38,27[illegible]
Saddle tank locomotives	4	12,65[illegible]
Steel rails ... tons	19,254¼	544,3[illegible]
Ties	501,876	458,94[illegible]
Electric cranes	3	12,54[illegible]
Hoisting engines	18	19,463[illegible]
Lumber ... feet b. m.	38,985,521	876,174[illegible]
Piles	34,657	296,31[illegible]
Switch and cross ties	501,574	448,07[illegible]
Brick	246,000	6,8[illegible]
Dynamite	8,852,000	1,051,57[illegible]
Powder, blasting	54,000	6,50[illegible]
Total		7,526,152[illegible]

No. 2.—*Important items of material received by the division of material and suppli[illegible] from inception of the canal work to June 30, 1908.*

Article.	Quantity.	Value.
Lumber ... feet b. m.	112,670,129	$2,535,077[illegible]
Explosives:		
Dynamite ... pounds	11,635,100	1,373,312.[illegible]
Powder, blasting ... do	681,500	63,837.[illegible]
Fuses ... feet	3,868,800	27,740[illegible]
Caps, blasting	917,000	4,865.[illegible]
Exploders, electric	586,400	45,069.[illegible]
20-30 hole batteries	32	531.[illegible]
40-50 hole batteries	127	3,685.[illegible]
Lead wire ... feet	160,500	1,057.[illegible]
Connecting wire ... pounds	2,648	804.[illegible]
Insulated tape ... feet	57,000	201.[illegible]
		1,621,104.[illegible]

o. 2.—*Important items of material received by the division of material and supplies from inception of the canal work to June 30, 1908*—Continued.

Article.	Quantity.	Value.
iles:		
Untreated	39,539	$338,097.02
Treated	11,351	227,930.26
Steel ....pieces	300	9,448.80
team shovels	101	1,089,479.96
ars	3,445	3,943,206.79
nloaders	29	158,839.00
allast plows	42	39,345.00
arth spreaders	23	119,391.00
ocomotives	164	1,839,252.60
ranes	28	211,305.00
ile drivers	2	18,000.00
redges	12	1,734,788.00
ugboats	6	341,000.00
arges	29	458,015.00
ir compressors	21	88,474.77
ock drills	489	190,675.62
ock channelers	26	64,610.00
ock crushers	7	39,795.93
teel rails ....tons	38,815	1,125,074.47
rack bolts ....pounds	1,095,000	30,222.10
rack spikes ....do	3,899,000	82,535.80
ngle bars	302,398	113,472.03
ie plates	1,595,872	123,095.61
teel railroad bridge	1	15,606.70
ail braces	43,500	4,262.50
witch chairs	500	340.00
rack-bolt washers ....pounds	7,200	162.30
plit switches ....sets	1,352	34,024.15
witch points	510	5,431.75
witch stands	1,478	13,205.26
Frogs	1,545	32,111.90
ross-ties	905,514	786,263.86
witch ties	41,753	66,201.52
Bridge ties	18,590	22,262.39
Water cranes	14	2,780.00
Turntables	2	2,946.00
Railway water tanks	19	10,751.76
Oil fuel tanks	15	14,215.00
Erecting cranes	3	12,545.00
Launches	4	14,939.67
Hoisting engines	40	38,559.50
Concrete mixers	10	11,060.00
Concrete block machines	3	2,250.00
Road rollers	6	14,479.00
Motor cars	5	4,480.00
Power plants	3	366,523.97
Cableways (cost estimated)	7	292,000.00
Cement		323,627.40
Furniture:		
Married quarters		187,823.67
Bachelor quarters		127,311.60
Hospitals		70,434.43
Wire screening		285,914.91
Forage and corral supplies (wagons, carts, other vehicles, etc.)		386,164.48
Rolling stock and machinery (locomotives, cranes, cars, steam shovels, plows, spreaders, etc.)		8,051,205.63
Floating equipment (barges, dredges, launches, rowboats, tugboats, etc.)		2,584,511.90
Brick (common, fire, paving, etc.)		203,924.95
Roofing, corrugated iron		373,739.10
Laborers' berths, cots, tents, etc		206,830.09
Iron (pig, round, flat, square, boiler, sheet, etc.)		272,758.37
Oils (linseed, cylinder, engine, car, valve, lubricating, etc.)		299,861.69
Large machinery and tools (lathes, drills, planers, engines, steam hammers, crushers, planing mills, electric plants)		1,219,649.36
Live stock (1904 to 1908, inclusive):		
Mules		86,184.00
Horses		22,650.00
Cows		3,425.00
Total		32,916,657.53

No. 3.—*Statement of important items of material due on United States requisition[illegible] July 1, 1908.*

Article.	Quantity.	Value.
Locomotives	18	$80,3[illegible]
Cars	58	29,0[illegible]
Coaling cranes	4	30,5[illegible]
Tugboats	1	66,3[illegible]
Barges, steel	16	378,5[illegible]
Stern-wheel tow boats	1	25,7[illegible]
Air compressor	1	9,12[illegible]
Rock drills	61	15,3[illegible]
70-pound steel rails ... tons	1,021	31,[illegible]
Track bolts ... pounds	57,000	1,42[illegible]
Track spikes ... do	70,000	1,6[illegible]
Angle bars	11,000	4,12[illegible]
Tie plates	245,000	15,9[illegible]
15-foot split switches ... sets	230	5,15[illegible]
Switch stands	180	1,33[illegible]
Frogs	242	4,5[illegible]
Cross-ties	72,000	64,0[illegible]
Bridge ties	8,000	5,3[illegible]
Electric cranes, 20-ton	1	3,40[illegible]
10-inch water cranes	2	4[illegible]
Railway water tanks	5	2,5[illegible]
8½ by 12 hoisting engines	6	8,0[illegible]
Motor cars	1	3,50[illegible]
Launch	1	1,10[illegible]
Power plant (cost estimated)	3	153,3[illegible]
Total		942,4[illegible]

No. 4.—*Statement showing kind and number of vehicles cared for by the division of mater[illegible] and supplies, June 30, 1908.*

Wagons	[illegible]
Carts	1[illegible]
Carriages	[illegible]
Wagonettes	[illegible]
Ambulances	[illegible]
Scrapers	[illegible]
Miscellaneous vehicles	[illegible]
Total	[illegible]

No. 5.—*Statement showing live stock stabled and foraged by the division of material a[illegible] supplies, June 30, 1908.*

Animals.	Owned by—	Number.
Mules	Division of material and supplies	[illegible]
Horses	....do	[illegible]
Do	Police department	[illegible]
Do	Private parties (owner's expense)	[illegible]
Do	Private parties (Isthmian Canal Commission's expense)	[illegible]
Mules	Panama railroad	[illegible]
Horse	Fire department	[illegible]
Total		[illegible]

NOTE.—The animals shown as belonging to the division of material and supplies are used by vari[illegible] departments, the corral expenses being prorated among the departments and divisions using tra[illegible] portation.

No. 6.—*Statement of amount of pay rolls of the division of material and supplies, from July 1, 1907, to June 30, 1908.*

Month.	Silver.	Gold.	Combined gold.
1907.			
July	$58,243.48	$25,280.90	$54,402.64
August	61,006.08	24,456.45	54,959.49
September	63,357.30	25,565.65	57,244.30
October	65,212.34	29,099.73	61,705.90
November	59,650.02	25,525.67	55,350.68
December	49,577.41	25,969.04	50,757.75
1908.			
January	49,746.41	28,704.88	53,578.08
February	51,097.12	25,791.39	51,339.95
March	55,702.59	25,560.21	53,411.50
April	55,359.90	25,296.10	52,976.05
May	62,796.94	25,602.55	57,001.02
June	69,857.02	27,470.20	62,398.71
Total	701,606.61	314,322.77	665,126.07

No. 7.—*Statement of payments made in the division of material and supplies, for sick leave, injury leave, vacation leave, and transit time, from July 1, 1907, to June 30, 1908.*

Stations.	Sick leave.	Injury leave.	Vacation leave.	Transit time.	Total.
Panama division	$93.34	$27.85	$1,853.88	$25.00	$2,000.07
Ancon corral	366.15	154.69	321.34	55.00	897.18
Ancon store	43.75	....	196.67	....	240.42
La Boca store	150.00	....	739.66	....	889.66
Paraiso store	368.74	....	270.83	41.67	681.24
Empire store and lumber yard	868.02	88.97	1,882.51	201.67	3,041.17
Gorgona store	487.19	....	1,588.05	109.17	2,184.41
Gatun corral	....	....	....	....	....
Mount Hope store	1,957.40	90.83	5,646.31	160.00	7,854.54
Cristobal, main office	1,873.62	5.50	11,941.18	384.17	14,204.47
Total	6,208.21	367.84	24,440.43	976.68	31,993.16

No. 8.—*Organization of the division of material and supplies.*

(W. G. Tubby, chief of division; M. A. Follman, secretary; force, 1,220.)

Main office: Force, 95; Max Dyer, chief clerk; clerks, 58; checkers, foremen, watchmen, laborers, etc., 36.

Receiving and forwarding division: H. Leonard, chief; clerks, 11.

Bookkeeping division: J. J. Jackson, chief; clerks, 23.

Purchase requisition division: Paul Wuttke, chief; clerks, 2.

Shipping division: C. E. Kendall, chief; clerks, 9; foremen, checkers, and laborers, 27.

Local express: A. W. Davis, foreman; men, 5.

Timekeeping division: C. F. Hagemann, chief; clerks, 6.

Mount Hope store: Force, 398. E. D. Hammond, storekeeper; Wm. A. Graham, assistant storekeeper; clerks, 24; foremen, checkers, and laborers, 367.

Drydock store: J. H. Cotter, storekeeper; foreman; men, 3.

Gorgona store: Force, 116; C. L. Prentiss, storekeeper; clerks, 9; foremen, checkers, and laborers, 106.

Paraiso store: Force, 27. J. L. Nolan, storekeeper; clerks, 7; foremen, checkers, and laborers, 19.

Empire store: Force, 133. F. W. Miracle, storekeeper; clerks, 14; foremen, checkers, and laborers, 69.

Lirio lumber yard: Geo. B. Dixon, foreman; men, 21.

Culebra store: O. S. Boyd, storekeeper; men, 10.

Powder magazine: Men, 8.

Bas Obispo store: X. D. Holt, storekeeper; men, 5.

Powder magazine: Men, 2.

Ancon store: Force, 5. R. O. Shady, storekeeper; clerks, 2; men, 2.

Panama office: Force, 66. W. Krugel, stationer and printer; W. C. Haskins, c
clerk; clerks, 9.
Printing plant: Geo. F. Halsey, foreman printer; men, 41.
Stationery store: Men, 13.
La Boca store and lumber yard: Force, 83. L. C. Vannah, storekeeper; clerks,
foremen, checkers, and laborers, 78.
Typewriter repair shop: Men, 3.
Animal transportation (185 horses, 447 mules): Force, 397. W. B. Burson, sup-
intendent; H. W. Laughlin, veterinary surgeon; J. R. Brown, assistant veteri-
surgeon; clerk, 1.
Cristobal corral: W. P. Costley, corral foreman; men, 62; horses, 13; mules
Tabernilla: Horse, 1; mules, 4. Bohio: Mule, 1. Colon hospital: Hor-
mules, 7. Colon quarantine station: Man, 1; mule, 1. Police departm-
Horse, 1. Panama Railroad store: Mules, 3. Panama Railroad commiss-
mules, 7.
Gatun corral: Geo. H. Turner, corral foreman; horses, 4; mules, 41; men,
Police department horses cared for and foraged, 3; private animals cared f
at Isthmian Canal Commission expense, 1.
Gorgona corral: Men, 9; horses, 2; mules, 15. James Manion, corral foreman.
Bas Obispo stables: Men, 3; horses, 4; mules, 6. Police department hor-
cared for at Gorgona corral, 2; private animals cared for at owner's expens-
Empire corral: Men, 36; horses, 7; mules, 49. N. B. Middleton, corral forem-
Police department horses cared for and foraged, 7; private animals stabled a
fed at owner's expense, 6.
Las Cascadas stables: Men, 5; horses, 2; mules, 6. Police department hor-
cared for and foraged, 1.
Culebra corral: Men, 49; horses 8; mules, 45. James A. Simmons, corral forem-
Private horses stabled and fed at owner's expense, 20.
Paraiso corral: Men, 11; horses, 2; mules, 11. Paraiso storekeeper in charg-
Private animals stabled and foraged at owner's expense, 1.
Ancon corral: Men, 125; horses, 52; mules, 120. A. Mantooth, corral forema-
Police department horses, 11; private animals stabled at owner's expense,
fire department horse, 1.
Pedro Miguel stables: Men, 4; mules, 5.
Corozal and spillway stables: Wm. A. Toombs, corral foreman; men,
horses, 3; mules, 48.
La Boca stables: Men, 3; horses, 3; mules, 4.

The organization of the division of material and supplies, as it now exists, is largely composed of men who have been in the service of th- Isthmian Canal Commission from two to four years. Practically a- of our storekeepers, clerical force, and foremen have been in the serv- ice from one to four years and, as a result of improvement in facili- ties and the acquirement of an experienced and well-organized force, the division is now in position to handle the business over which i- has jurisdiction in a highly satisfactory manner.

During the past year the health of employees in this division ha- been good, there having been less sickness or absence from duty on account of illness than during previous years.

I have the honor to be, very respectfully,

W. G. TUBBY,
Chief, Division of Material and Supplies.

Lieut. Col. GEO. W. GOETHALS,
Corps of Engineers, U. S. Army,
Chairman and Chief Engineer,
Isthmian Canal Commission, Culebra, Canal Zone.

The following statements are in support of the figures used in the foregoing report:

DIVISION OF MATERIAL AND SUPPLIES.

Important items of material received from inception of canal work to June 30, 1908.

Lumber:

Received to June 30, 1908	feet b. m..	112,670,129
On order July 1, 1908	do....	2,754,310
Total received and on order	do....	115,424,439
Lumber received from July 1, 1907, to June 30, 1908	do....	38,985,521

Explosives received from the inception of canal work to June 30, 1908.

Material.		Quantity.	Values.
Dynamite:			
30 per cent	pounds..	20,000	$1,950.00
45 per cent	do....	6,667,000	736,726.50
60 per cent	do....	4,632,000	589,070.00
75 per cent	do....	300,000	42,375.00
Unclassified	do....	16,100	3,191.00
		11,635,100	1,373,312.50
Powder:			
Blasting	do....	509,500	45,412.50
Giant No. 0	do....	15,000	2,850.00
Giant No. 1	do....	32,500	6,175.00
Giant No. 2	do....	22,500	3,100.00
Trojan	do....	50,000	6,000.00
Rackarock	do....	2,000	300.00
		631,500	63,837.50
Caps, blasting	number..	917,000	4,865.45
Exploders, electric	do....	586,400	45,069.00
Fuzes	feet..	3,868,800	27,740.03
20-30 hole batteries	number..	32	531.50
40-50 hole batteries	do....	127	3,685.66
Copper wire:			
No. 12	feet..	155,000	1,020.42
No. 24	pounds..	1,460	455.78
Connecting wire No. 20	do....	1,188	348.41
Lead wire No. 20	feet..	5,500	26.83
Insulated tape	do....	57,000	201.70
		....	83,954.78
Total value		....	1,521,104.78
Untreated piles	number..	39,539	338,097.02
Treated piles	do....	11,351	227,930.24
		50,890	566,027.26
Steel piling	pieces..	300	9,446.80
Piles received from July 1, 1907, to June 30, 1908		34,657	296,317.25

Statement of important items of material received from July 1, 1907, to June 30, 1908.

Description.	Quantity.	Value.
Bucyrus steam shovels:		
45-ton	7	$49,000.00
70-ton	7	67,700.00
	14	116,700.00
Marion steam shovels:		
Model No. 20	1	5,787.50
Model No. 60	7	70,292.50
Model No. 91	16	210,850.00
	24	286,930.00
Cars:		
40-ton wooden flats	300	337,969.00
12-yard all metal dump	500	562,500.00
	800	900,469.00
Lidgerwood unloaders, 12 by 12	10	82,050.00
Plows, side ballast	6	6,420.00
Spreaders (Mann-McCann)	10	66,070.00
Four-wheel saddle tank locomotives	4	12,682.00

Statement of important items of material received from July 1, 1907, to June 30, 19[illegible]—Continued.

Description.	Quantity.	Value.
Cranes:		
25-ton locomotive	4	$[illegible]
20-ton locomotive	3	27,[illegible]
10-ton locomotive	2	13,[illegible]
	9	81,[illegible]
Dredges:		
5-yard dipper	3	305,0[illegible]
20-inch suction	4	389,[illegible]
Seagoing suction	1	367,[illegible]
	8	1,061,9[illegible]
Tugboats	5	299,0[illegible]
Steel barges	12	249,9[illegible]
Air compressor	1	4,0[illegible]
Rock drills:		
Ingersoll-Rand Co., F-32	24	4,7[illegible]
Ingersoll-Rand Co., A-50	9	90[illegible]
Star steam churn	51	34,[illegible]
Sullivan, UH-11	50	9,3[illegible]
Wood, 3¼	37	5,064[illegible]
Chicago Giant, E-3½	1	1[illegible]
	172	54,7[illegible]
Rock channelers, Y-8	13	32,3[illegible]
Rails:		
30-pound steel ... tons	200	7,164[illegible]
70-pound steel ... do	17,254½	537,1[illegible]
	19,254½	544,3[illegible]
Track bolts ... pounds	508,000	13,[illegible]
Track spikes ... do	1,684,000	34,715[illegible]
Angle bars	119,150	44,71[illegible]
Tie plates	470,000	56,41[illegible]
Rail braces	5,000	4[illegible]
15-foot split switches, 70-pound	481	11,324[illegible]
Switch points, 70-pound	410	4,0[illegible]
Frogs:		
No. 5	24	19[illegible]
No. 6	36	6[illegible]
No. 7	507	10,32[illegible]
No. 8	12	25[illegible]
No. 9	24	54[illegible]
No. 10, spring rail	25	80[illegible]
	628	12,825.[illegible]
Switch stands	880	7,550.[illegible]
Ties:		
Cross	459,606	397,25[illegible]
Bridge	23,680	39,4[illegible]
Switch	18,590	22,2[illegible]
	501,876	458,94[illegible]
Railway water tanks	3	1,540.[illegible]
Oil fuel tanks	15	14,215.[illegible]
Electric cranes:		
10-ton	1	3,640.0[illegible]
20-ton	2	8,905.[illegible]
	3	12,545.0[illegible]
Launches	2	2,600.0[illegible]
7 by 10 hoisting engines	10	9,13[illegible]
8¼ by 12 hoisting engines	8	10,327.[illegible]
	18	19,463.[illegible]
Concrete mixers	4	3,660.[illegible]
Road rollers, 8-ton	1	2,500.0[illegible]
No. 2 motor car	1	210.0[illegible]
Style "C" motor car	2	2,600.0[illegible]
	3	2,810.0[illegible]
Plants:		
La Boca air compressor	1	34,634.9[illegible]
Gatun material handling	1	293,614.0[illegible]
La Boca 15-ton rock crusher	1	38,275.0[illegible]
	3	366,523.9[illegible]

Summary of material received from July 1, 1907, to June 30, 1908.

Description.	Quantity.	Value.
Steam shovels	38	$403,690.00
Cars	800	900,489.00
Unloaders	10	52,050.00
Ballast plows	6	6,420.00
Spreaders	10	66,070.00
Cranes	9	81,624.63
Dredges	8	1,061,944.00
Tugboats	5	299,000.00
Steel barges	12	249,995.00
Air compressor	1	4,087.00
Rock drills	172	54,706.60
Rock channelers	13	32,305.00
Track bolts ... pounds	508,000	13,468.00
Track spikes ... do	1,684,000	34,715.80
Angle bars ... do	119,150	44,718.98
Tie plates	470,000	56,419.11
Rail braces	5,000	487.50
15-foot split switches	481	11,324.70
Switch points	410	4,696.75
Frogs	628	12,825.95
Switch stands	880	7,850.25
Railway water tanks	3	1,540.50
Oil fuel tanks	15	14,215.00
Launches	2	2,600.00
Concrete mixers	4	3,660.00
Road roller	1	2,500.00
Motor cars	3	2,810.00
Air-compressor plant (La Boca)	1	34,634.88
Material-handling plant (Gatun)	1	293,614.00
15-ton rock crusher (La Boca)	1	38,275.09
Saddle-tank locomotives	4	12,652.00
Steel rails ... tons	19,254½	544,337.44
Ties	501,876	458,948.76
Electrical cranes	3	12,545.00
Hoisting engines	18	19,463.00
Total		4,840,683.94

Statement of important items of material received from inception of canal work to June 30, 1908.

Description.	Quantity.	Value.
Bucyrus steam shovels:		
45-ton	10	$71,100.00
70-ton	35	330,890.00
95-ton	32	400,559.96
	77	802,549.96
Marion steam shovels:		
Model No. 20	1	5,787.50
Model No. 60	7	70,262.50
Model No. 91	16	210,880.00
	24	286,930.00
Cars:		
50-ton steel flat	500	430,500.00
12-yard, all metal dump	500	562,500.00
40-ton wooden flat	1,785	1,934,532.00
Large western dump	300	645,000.00
Small western dump	300	311,100.00
Western dump (narrow gauge)	35	7,945.00
"Ingoldsby" dump	35	17,460.00
"Goodwin" dump	12	31,500.00
"King Lawson" dump	1	2,669.79
	3,445	3,943,206.79
Lidgerwood unloaders:		
10 by 12	6	39,124.00
12 by 12	16	83,290.00
12 by 12	7	36,436.00
	29	[illegible]

Statement of important items of material received from inception of canal work to June 1908—Continued.

Description.	Quantity.	Value
Plows:		
Center-ballast	6	35,41[illegible]
Side-ballast	36	33,9[illegible]
	42	39,34[illegible]
Spreaders:		
Mann-McCann	19	104,[illegible]
Jordan	4	15,3[illegible]
	23	119,3[illegible]
Locomotives:		
19 by 24 Mogul	100	1,130,7[illegible]
19 by 24 switching	40	459,[illegible]
20 by 26 Mogul	20	236,3[illegible]
4-wheel saddle-tank	4	12,6[illegible]
	164	1,839,2[illegible]
Cranes:		
100-ton Bucyrus wrecking	1	14,9[illegible]
75-ton Bucyrus wrecking	1	12,4[illegible]
70-ton Bucyrus wrecking	1	12,4[illegible]
20-ton American hoist and derrick	1	6,7[illegible]
10-ton locomotive coaling	7	45,2[illegible]
15-ton locomotive coaling	2	13,5[illegible]
20-ton locomotive coaling	11	66,1[illegible]
25-ton locomotive	4	39,5[illegible]
	28	211,3[illegible]
Pile drivers, Industrial Works	2	18,0[illegible]
Dredges:		
3 to 5 yard dipper	2	206,0[illegible]
5-yard dipper	4	405,0[illegible]
20-inch suction	4	389,2[illegible]
Sea-going suction	2	735,5[illegible]
	12	1,734,7[illegible]
Tugboats	6	341,0[illegible]
Barges:		
Steel, 15 by 40	6	14,53[illegible]
Steel, 25 by 75	5	44,50[illegible]
Steel	12	249,9[illegible]
Steel, dump, 350 to 400 yards	6	149,0[illegible]
	29	458,015[illegible]
Air compressors:		
Rand, Type X	4	17,5[illegible]
Rand, Type 10	4	22,004[illegible]
Franklin, Type D-D. S. Co.	3	8,62[illegible]
Laidlaw-Dunn-Gordon	6	31,90[illegible]
Portable, 7½ by 8 inches	2	2,3[illegible]
Portable, F. M. & Co.	1	1,70[illegible]
Chicago Pneumatic Tool Co., No. 2621	1	4,0[illegible]
	21	88,4[illegible]
Rock drills:		
Pierce, 4-inch W. B.	2	834[illegible]
Pierce, 6-inch W. B.	1	919[illegible]
Little Giant, No. 4	25	9,195[illegible]
Little Giant, No. 5	25	13,233[illegible]
Chicago, 3¼-inch	25	8,9[illegible]
Star, No. 0	10	9,825[illegible]
Sullivan, No. 7	25	8,517[illegible]
Ingersoll-Rand Co., F-32	105	33,74[illegible]
Ingersoll-Rand Co., G. A. 2	25	14,264[illegible]
Ingersoll-Rand Co., A.-50	37	6,790[illegible]
Keller, 1¼-inch	25	2,4[illegible]
Star steam churn	94	66,255[illegible]
Keystone steam churn	2	1,070[illegible]
Sullivan, UH-11	50	9,325[illegible]
Wood, 3¼-inch	37	5,084[illegible]
Chicago Giant, R-3¼-inch	1	180[illegible]
	489	190,67[illegible]
Rock channelers, "Y-8"	26	64,610[illegible]

Statement of important items of material received from inception of canal work to June 30, 1908—Continued.

Description.	Quantity.	Value.
Rock crushers:		
Champion, No. 3	2	$1,535.00
McGully, No. 5	1	8,075.00
McGully, No. 8	1	8,653.57
Gates, No. 5	2	3,624.00
Gates, No. 8	1	17,908.35
	7	39,795.92
Rails:		
30-pound, steel ... tons	200	7,164.16
70-pound, steel ... do	38,611	1,117,750.93
85-pound, steel ... do	4	159.38
	38,815	1,125,074.47
Track bolts ... pounds	1,095,000	30,222.10
Track spikes ... do	3,899,000	82,535.80
Angle bars	302,398	113,472.03
Tie plates	1,595,872	123,095.61
Single track steel bridge	1	15,608.70
Rail braces	43,500	4,262.50
Switch chairs	500	340.00
Track-bolt washers ... pounds	7,200	162.30
15-foot 70-pound split switches ... sets	1,352	34,024.15
15-foot switch points	510	5,431.75
Frogs:		
70-pound, No. 5	24	198.00
70-pound, No. 6	164	3,190.60
70-pound, No. 7	1,029	20,976.80
70-pound, No. 8	24	517.20
70-pound, No. 9	279	6,420.55
Spring rail, No. 10	25	808.75
	1,545	32,111.90
Switch stands	1,478	13,206.25
Ties:		
Cross	905.514	786,263.86
Switch	41,753	66,201.52
Bridge	18,590	22,262.39
	965.857	874,727.77
Water cranes:		
Otto, 10-inch	12	2,400.00
Mansfield, 8-inch	2	350.00
	14	2,750.00
Turntables, 60-foot	2	2,946.00
Railway water tanks	19	10,731.76
Oil fuel tanks	15	14,215.00
Erecting cranes:		
10-ton	1	3,640.00
20-ton	2	8,905.00
	3	12,545.00
Launches	4	14,939.67
Hoisting engines:		
6¼ by 10	4	3,600.00
7 by 10	22	19,211.00
8¼ by 12	12	13,322.60
Lidgerwood, No. 71	2	2,226.50
	40	38,359.50
Concrete mixers:		
½-yard	6	6,370.00
No. 2	1	1,285.00
No. 3	3	3,406.00
	10	11,060.00
Concrete-block machines	3	2,250.00
Road rollers:		
4½ to 5 ton	1	1,239.00
7½ to 10 ton	3	5,145.00
12 to 13 ton	1	2,395.00
8-ton	1	2,500.00
	6	14,479.00

Statement of important items of material received from inception of canal work to Jun[illegible] 1908—Continued.

Description.	Quantity.	Valu[illegible]
Motor cars:		
No. 16	1	$8[illegible]
No. 2	2	1,[illegible]
Style C	2	2,[illegible]
	5	4,4[illegible]
Power plants:		
La Boca, air compressor	1	34,[illegible]
Gatun, material handling	1	293,[illegible]
La Boca, 15-ton rock crusher	1	3[illegible]
	3	366,[illegible]
Cableways:		
1 single unloading	1	25,[illegible]
2 duplex	2	92,[illegible]
4 duplex (over locks)	4	175,[illegible]
	7	a 292,0[illegible]

a Estimated cost.

Summary of important items of material received from inception of canal work to J[illegible] 1, 1908.

Article.	Quantity.	Value.
Steam shovels	101	$1,089,[illegible]
Cars	3,445	3,943,[illegible]
Unloaders	29	156,[illegible]
Ballast plows	42	39,[illegible]
Earth spreaders	23	119,[illegible]
Locomotives	164	1,839,[illegible]
Cranes	28	211,[illegible]
Pile drivers	2	18,[illegible]
Dredges	12	1,734,[illegible]
Tugboats	6	341,0[illegible]
Barges	29	458,[illegible]
Air compressors	21	88,4[illegible]
Rock drills	489	190,[illegible]
Rock channelers	26	64,[illegible]
Rock crushers	7	39,7[illegible]
Steel rails ... tons	38,815	1,125,0[illegible]
Track bolts ... pounds	1,095,000	30,[illegible]
Track spikes ... do	3,899,000	82,5[illegible]
Angle bars	302,398	113,4[illegible]
Tie plates	1,595,872	123,0[illegible]
Steel railroad bridge	1	15,[illegible]
Rail braces	43,500	4,[illegible]
Switch chairs	500	34[illegible]
Track-bolt washers ... pounds	7,200	1[illegible]
Split switches ... sets	1,352	34,0[illegible]
Switch points	510	5,4[illegible]
Switch stands	1,478	13,[illegible]
Frogs	1,545	33,11[illegible]
Cross-ties	905,514	786,[illegible]
Switch ties	41,753	66,[illegible]
Bridge ties	18,590	22,[illegible]
Water cranes	14	2,7[illegible]
Turntables	2	2,94[illegible]
Railway water tanks	19	10,731[illegible]
Oil-fuel tanks	15	14,21[illegible]
Erecting cranes	3	12,545[illegible]
Launches	4	14,939[illegible]
Hoisting engines	40	38,559[illegible]
Concrete mixers	10	11,0[illegible]
Concrete-block machines	3	2,2[illegible]
Road rollers	6	14,47[illegible]
Motor cars	5	4,4[illegible]
Power plants	3	366,[illegible]
Cableways (cost estimated)	7	292,000[illegible]
Total		13,577,98[illegible]

Statement of important items of material purchased for account of the Isthmian Canal Commission from inception of canal work, 1904, to June 30, 1908.

Article.	1904.	1905.	1906.	1907.	1908.	Total.
Cement	[a] $4,490.00	[b] $63,360.00	[c] $87,967.00	[d] $102,045.00	[e] $65,765.40	$323,627.40
Furniture:						
Married quarters	967.50	24,932.06	33,702.14	55,762.82	72,459.15	187,823.67
Bachelor quarters	224.02	53,311.51	35,023.87	20,441.80	18,310.40	127,311.60
Hospitals	9,655.11	46,458.75	1,307.90	4,838.50	8,174.17	70,434.43
Wire screening	5,200.00	32,110.00	151,167.00	42,500.00	54,937.91	285,914.91
Forage and corral supplies (wagons, carts, other vehicles, etc.)	6,150.00	112,332.89	97,211.14	88,820.87	81,649.58	386,164.48
Rolling stock and machinery (locomotives, cranes, cars, steam shovels, unloaders, plows, spreaders, etc.)	585,150.00	3,142,874.00	1,989,606.00	1,127,332.00	1,206,243.63	8,051,205.63
Floating equipment (barges, dredges, launches, rowboats, tugboats, etc.)	1,657.39	85,976.00	1,423,457.88	422,165.68	651,254.95	2,584,511.90
Brick (common, fire, paving, etc.)	....	190,597.47	4,276.10	6,838.00	2,213.38	203,924.95
Corrugated iron roofing	5,689.70	67,577.38	92,708.75	76,309.23	131,454.04	373,739.10
Blasting material	92,727.71	67,577.38	171,301.06	385,065.22	680,244.75	1,396,916.12
Laborers' berths, cots, tents, etc	509.10	84,878.99	81,809.00	17,243.00	22,390.00	206,830.09
Iron (pig, round, flat, square, boiler, sheet, etc.)	....	38,326.20	17,354.92	40,610.92	176,466.33	272,758.37
Oils (linseed, cylinder, engine, car, valve, lubricating, kerosene, etc.)	9,500.08	32,519.60	26,578.50	138,300.16	92,963.35	299,861.69
Large machinery and tools (lathes, drills, planers, engines, steam hammers, crushers, planing mills, electric plants)	17,086.39	133,171.59	33,118.17	858,520.43	177,752.78	1,219,649.36
Live stock (1904 to 1908, inclusive):						
Mules	....	....	....	....	....	86,184.00
Horses	....	....	....	....	....	23,650.00
Cows	....	....	....	....	....	3,425.00
						113,259.00

[a] 2,600 barrels. [b] 39,500 barrels. [c] 47,350 barrels. [d] 53,000 barrels. [e] 35,160 barrels.

Statement of important items of material due on United States requisitions, July 1, 1908.

Description.	Quantity.	Value.
Locomotives:		
4-wheel saddle tank	8	$25,304.00
40-ton	10	55,000.00
	18	80,304.00
Cars:		
15-ton steel	8	4,000.00
6-yard dump	50	25,000.00
	58	29,000.00
Cranes:		
20-ton locomotive coaling	3	23,550.00
15-ton locomotive coaling	1	7,000.00
	4	30,550.00
Tugboat	1	66,300.00
Barges:		
Steel	11	258,500.00
Steel, dump	4	80,000.00
Steel, rock drill	1	40,000.00
	16	378,500.00
Stern-wheel towboat	1	25,753.00
Air compressor	1	9,124.00
Rock drills:		
Air hammer	18	774.00
Rock, complete	12	7,920.00
Ingersoll, F-32	25	5,875.00
Rock, complete	6	825.00
	61	15,394.00
Steel rails, 70-pound ... tons	1,021	31,621.00
Track bolts ... pounds	57,000	1,425.00
Track spikes ... do	70,000	1,633.33
Angle bars	11,000	4,125.00
Tie plates	200,000	12,739.85
Do	45,000	3,181.50
	245,000	15,921.35
15-foot split switches ... sets	30	660.00
Do ... do	200	4,495.00
	230	5,155.00
Switch stands	30	220.50
Do	150	1,115.00
	180	1,335.00
Frogs:		
No. 5	5	40.00
No. 6	10	190.00
No. 7	165	3,030.00
No. 9	62	1,296.50
	242	4,556.50
Ties:		
Cross	72,000	64,080.00
Bridge	8,000	5,328.00
	80,000	69,408.00
20-ton electric crane	1	3,400.00
10-inch water crane	2	480.00
Railway water tanks	5	2,500.00
8½ by 12 hoisting engines	6	8,100.00
Motor car	1	3,500.00
Launch	1	1,100.00
Plants:		
Porto Bello (bucket conveying)	1	13,300.00
Gatun (boiler)	1	140,000.00
La Boca (boiler)	1	
	3	153,300.00

Summary of material under contract.

Article.	Quantity.	Value.
Locomotives	18	$80,304.00
Cars	58	29,000.00
Coaling cranes	4	30,550.00
Tugboat	1	66,300.00
Barges, steel	16	378,500.00
Stern-wheel towboat	1	25,753.00
Air compressor	1	9,124.00
Rock drills	61	15,394.00
70-pound steel rails ... tons	1,021	31,621.00
Track bolts ... pounds	57,000	1,425.00
Track spikes ... do	70,000	1,633.33
Angle bars	11,000	4,125.00
Tie plates	245,000	15,921.35
15-foot split switches ... sets	230	5,155.00
Switch stands	180	1,335.50
Frogs	242	4,556.50
Cross ties	72,000	64,080.00
Bridge ties	8,000	5,328.00
Electric cranes, 20-ton	1	3,400.00
10-inch water cranes	2	480.00
Railway water tanks	5	2,500.00
8½ by 12 hoisting engines	6	8,000.00
Motor car	1	3,500.00
Launch	1	1,100.00
Power plants (cost estimate)	3	153,300.00
Total		942,485.68
Received		13,577,982.29
On order		942,485.68
Total		14,520,467.97

Statement of number, kind, and location of vehicles cared for by the division of material and supplies June 30, 1908.

Location.	Wagons.	Carts.	Carriages.	Wagonettes.	Ambulances.	Scrapers.	Miscellaneous vehicles.	Total.
Cristobal corral	31	20	7	1	2	11	10	82
Bocas del Toro		3						3
Gatun corral	18	6		1	1			26
Bohio								
Tabernilla		3						3
Gorgona corral	7	6				1	1	15
Bas Obispo corral	3	2				1		6
Las Cascadas stable	2	3						5
Empire corral	20	23				6		49
Culebra corral	20	12	1	1	1	1		36
Paraiso corral	3	4						7
Pedro Miguel stables	3	6						9
Cocoli spillway						27		27
Corozal corral	4	1						5
La Boca stable	1	1						2
Ancon corral	51	29	17	5	4	7	9	122
Total	163	119	25	8	8	54	20	397

Location and number of live stock stabled and foraged by the division of material and supplies June 30, 1908.

Location.	Material and supplies division.		Police department horses.	Private horses at owner's expense.	Private animals, Isthmian Canal Commission expense.	Panama Railroad live stock at material and supplies corrals.	Fire department stock at material and supplies corrals.	Total.
	Mules.	Horses.						
Cristobal corral	86	14	1			10		111
Bocas del Toro	2							2
Gatun corral	41	4	3		1			49
Bohio	1							1
Tabernilla	3	1						4
Gorgona	15	2	2	2				21
Bas Obispo corral	6	4						10
Las Cascadas corral	9		1					10
Empire corral	40	7	7	6				60
Culebra corral	45	8		20				73
Paraiso corral	11	2		1				14
Pedro Miguel	5		1					6
Cocoli spillway	39	1						40
Corozal corral	16	3						19
La Boca stable	4	3		1				8
Ancon corral	113	51	11	28			1	204
Total	436	100	26	58	1	10	1	632

Statement of work at printing plant, Ancon, from July 1, 1907, to June 30, 1908.

Month.	Requests.	Pieces.	Sheets raw material.	Tags, envelopes, etc.	Manufactured value.
1907.					
July	306	2,000,965	267,950	116,225	$2,405.96
August	381	2,555,842	289,400	102,150	2,605.98
September	316	2,044,125	321,098	108,550	2,532.92
October	331	3,339,246	441,026	136,850	4,716.23
November	323	2,074,578	339,078	88,000	2,606.22
December	369	3,187,709	447,699	128,100	2,879.12
1908.					
January	374	4,032,071	411,874	90,290	3,908.37
February	286	1,286,847	342,469	111,500	2,438.75
March	365	2,801,045	484,086	166,455	4,098.46
April	409	2,161,518	483,558	92,265	3,486.83
May	376	2,584,310	406,521	139,750	3,785.88
June	429	2,445,241	376,796	69,641	3,048.38
Total	4,265	30,513,497	4,611,554	1,349,776	38,513.10

APPENDIX J.

REPORT OF THE DEPARTMENT OF LABOR, QUARTERS, AND SUBSISTENCE.

CULEBRA, CANAL ZONE, *July 1, 1908.*

SIR: The duties of this department have not changed from those described in the previous annual report. The growth of the subsistence feature, the increase of force over the whole work, the setting of a higher standard in the care of quarters, has caused an increase of at least 50 per cent in the number of employees of the department.

LABOR SUPPLY.

There has been a net decrease in the force of skilled labor, taking into consideration both the Panama Railroad Company and the Isthmian Canal Commission. Notwithstanding this, there were almost as many new employments as in the preceding year, the number of men employed being 5,200 and 5,800, respectively, for the two years. This will serve to indicate the shifting character of the force, and shows that it is being practically renewed yearly. There has been a radical change in the source of supply. There were 1,828 men employed in the United States as against 3,038 the year before, while the number of men employed on the Isthmus has increased from 2,766 to 3,382. Two labor agents represent the department in the United States instead of three, and it may be possible to handle all new employments with one agent.

The number of unskilled laborers has increased little. There are approximately 500 more Europeans and 1,000 West Indians on the work than at the close of the fiscal year 1906–7. To make this increase and fill the gaps caused by the departure of old men, 4,150 West Indians and 3,650 Europeans were imported. The total excess of immigration over emigration was nearly 18,000. As far as supply is concerned, the labor problem may be considered solved. The efficiency of the labor will bear watching until the very end of the work, but the question will be solved by the foremen on the work rather than by the importations of this department. There will probably be a movement of Europeans to South America from time to time. A portion of the West Indians will be constantly changing as before, but a tendency to stability was noted in the past year and will be perhaps more so in the year to come.

QUARTERS.

Approximately 700 American families have been brought down to the Isthmus during the past year. This department has recommended the construction of quarters accommodating 250 families. Conversions of bachelor quarters, old French houses, and laborers' barracks are constantly being made to take care of American families now being brought or to be brought to the work. While there are

still a number of applications on file, there is no congestion of married quarters and no such demand as there was a year ago. In a short time there will be practically no new construction needed, as the number of natural vacancies occurring from time to time will take care of the applications to be filed. There is no congestion in laborers' quarters. There has been an increased tendency on the part of the laborer to go to the brush and build himself a shack, or to go into tenements in the various small towns along the Zone. While this relieves the commission of the obligation to quarter these men, it is an open question whether the movement is beneficial.

The department has tried to set a higher standard of cleanliness in both gold and silver quarters. Vigorous attempts have been made to rid all quarters of vermin, and, in the main, these attempts have been attended with success. There has been an improvement in the methods of camp management.

SUBSISTENCE.

This feature has assumed the proportions of a great business. The monthly receipts touch $175,000 and the disbursements are correspondingly large. Operations show a profit, in the whole, of approximately $16,000, or about 1 per cent on the volume of business. The equipment has been bettered. The standard of food and service has been improved. A system of inspections was inaugurated during the year, and an attempt made to improve the cleanliness of all classes of messes.

Attached are a number of tables summarizing the operations of the department for the year.

Respectfully submitted.

R. E. Wood,
First Lieutenant, Third Cavalry, U. S. Army,
Assistant Manager.

To the Chairman, Isthmian Canal Commission,
Culebra.

Laborers brought to the Isthmus at the expense of the commission.

Month.	Bordeaux.	Santander.	St. Nazaire.	Vigo.	Martinique.	Barbados.	Barcelona.	Guadeloupe.	Total.
1907.									
July	133	238	114	240	....	....	64	137	926
August	87	332	3	188	....	750	90	....	1,450
September	92	198	....	336	119	....	58	....	803
October	....	52	....	103	580	....	....	....	735
November	....	27	....	98	270	....	24	....	419
December	....	73	....	99	....	122	20	....	314
Total	312	920	117	1.064	969	872	256	137	4,647
1908.									
January	....	122	....	99	....	210	20	....	451
February	....	....	....	....	....	456	21	....	477
March	38	125	....	96	....	164	24	....	447
April	45	51	....	....	....	352	18	....	466
May	....	81	....	....	....	401	25	....	507
June	....	179	....	....	....	590	37	....	806
Total	83	558	....	195	....	2,173	145	....	3,154
Grand total	....	....	....	....	....	....	....	....	7,801

NOTE.—There were also received 164 members of families of European laborers, the cost of whose transportation (which is included in the figures below) was $4,068.75.

Amount expended for the transportation of laborers to the Isthmus.

Month.	Bordeaux.	Santander.	St. Nazaire.	Vigo.	Martinique.	Barbados.	Barcelona.	Guadeloupe.
1907.								
July	$5,206.20	$8,330.00	$4,597.60	$8,175.71	....	....	$2,240.00	$1,150.00
August	3,510.75	11,129.00	121.21	6,404.30	....	$5,400.00	3,150.00	....
September	3,717.17	6,930.00	....	11,446.01	$1,130.50	....	2,030.00	....
October	....	1,820.00	....	3,508.75	4,930.00	....	....	....
November	....	1,356.30	....	3,338.40	2,415.00	....	927.50	....
December	....	2,416.40	....	3,372.50	....	1,024.80	857.50	....
1908.								
January	....	4,900.00	....	3,372.48	....	1,764.00	857.50	....
February	....	....	....	....	....	3,283.20	778.75	....
March	2,003.75	4,375.00	....	3,270.30	....	1,377.60	962.50	....
April	1,575.00	2,187.50	....	....	....	2,956.80	717.50	....
May	....	3,212.30	....	....	....	3,119.60	1,058.75	....
June	....	7,052.50	....	....	....	4,248.00	1,365.00	....

Total cost of transportation of laborers for the fiscal year, $165,073.63.

Deductions made from pay of contract laborers to cover cost of their transportation to the Isthmus, fiscal year 1907-8.

July	$17,885.39	February	$24,624.64
August	17,165.26	March	24,443.98
September	18,978.47	April	19,399.35
October	19,241.26	May	21,294.35
November	21,197.06	June	14,910.18
December	28,624.04		
January	24,745.91	Total	252,429.89

The money collected for transportation from European laborers largely exceeds the total disbursements for both Europeans and West Indians. A considerable percentage of the collections was from men brought over during the previous fiscal year under the old conditions ($4 monthly deductions).

Average monthly force, Isthmian Canal Commission, fiscal year 1907-8.

Month.	Construction and engineering.	Labor, quarters, and subsistence.	Civil administration.	Sanitation.	Disbursing.	Auditing.	Total.
July	19,203	1,747	444	2,579	128	60	24,161
August	18,747	2,015	408	2,676	127	60	24,033
September	18,845	1,927	403	2,254	124	54	23,607
October	21,224	1,933	424	2,062	127	58	25,828
November	20,593	2,065	416	2,072	122	61	25,329
December	18,940	2,095	412	2,133	126	57	23,763
January	20,552	2,084	474	2,131	131	56	25,428
February	20,938	2,010	505	2,188	128	59	25,828
March	20,422	2,069	505	2,372	123	61	25,552
April	20,768	2,249	495	2,440	117	49	26,118
May	20,584	2,265	488	2,364	122	58	25,881
June	20,300	2,410	494	2,209	109	56	25,578

Classified force, June 30, 1908.

From United States	4,587
Europeans	4,913
West Indians	16,078
	25,578

Panama Railroad force.

Gold force	816
Laborers	4,337
	5,153

NOTE.—Practically all of the laborers employed by the Panama Railroad Company are West Indians.

Statement of force actually at work on June 30, 1908.

Department.	Gold men.	Silver men.								Total.	T… g… a… sil…
		Artisans.			Laborers.						
		Monthly.	32 cents and over.	26 cents.	40 cents.	32 cents.	26 cents.	20 cents.	13½ cents.		
Construction and engineering	3,536	1,945	4,464	1,764	4,176	462	526	3,427	......	16,764	20.
Labor, quarters and subsistence	179	1,489	75	4	204	38	4	417	......	2,231	2,
Civil administration	328	143	22	......	......	......	......	1	......	166	4
Sanitation	395	880	123	......	33	......	7	771	......	1,814	2,
Disbursements	94	15	......	......	......	......	......	......	......	15	1
Examiner of accounts	55	1	......	......	......	......	......	......	......	1	
Totals	4,587	4,473	4,684	1,768	4,413	500	537	4,616	......	20,991	25,5

Panama Railroad Company force, 5,622.

Statements showing operations, by months, of hotels, European laborers' messes, and common laborers' kitchens.

HOTELS.

Month.	Expense.	Income.	Gain.	Loss.
July	$57,117.77	$53,799.31	....	$3,318.46
August	60,776.23	56,482.10	....	4,294.13
September	56,595.43	53,380.16	....	3,215.27
October	56,416.77	58,500.90	$2,084.13	....
November	57,611.08	60,418.72	2,807.64	....
December	60,219.44	58,688.57	....	1,530.87
January	58,909.23	58,526.62	....	382.61
February	54,387.85	54,893.67	505.82	....
March	63,096.51	59,852.19	....	3,244.32
April	61,331.18	58,665.88	....	2,665.30
May	65,436.96	59,154.25	....	6,282.71
June	62,381.61	59,973.21	....	2,408.40
Total	....	....	5,397.59	27,342.07 5,397.59
Net loss	....	....	....	21,944.48

EUROPEAN LABORERS' MESSES.

Month.	Expense.	Income.	Gain.	Loss.
July	$37,369.88	$38,497.11	$1,127.23	....
August	38,887.28	39,238.90	351.62	....
September	40,606.53	41,234.49	627.96	....
October	40,246.48	43,664.19	3,417.71	....
November	41,449.87	38,536.53	2,913.34	....
December	39,646.35	41,604.47	1,958.12	....
January	39,228.96	42,646.83	3,417.87	....
February	40,538.11	42,548.07	2,009.96	....
March	44,963.19	46,068.13	1,104.94	....
April	44,444.72	44,070.83	....	$373.89
May	41,792.64	42,317.29	524.65	....
June	43,610.53	43,575.17	....	35.36
Total	....	....	17,453.40 409.25	409.25
Net gain	....	....	17,044.15	....

nents showing operations, by months, of hotels, European laborers' messes, and common laborers' kitchens—Continued.

COMMON LABORERS' KITCHENS.

Months.	Expense.	Income.	Gain.	Loss.
....	$35,636.87	$36,806.00	$1,169.13	....
ıst........	35,741.80	37,926.70	2,184.90	....
amber........	33,425.48	34,872.20	1,446.72	....
ber........	32,708.03	34,977.13	2,269.10	....
amber........	30,498.05	32,786.08	2,288.03	....
mber........	29,385.12	32,481.90	3,096.78	....
ıary........	28,372.00	31,399.60	3,027.60	....
ruary........	26,442.88	27,181.40	738.52	....
ch........	26,457.69	27,102.04	644.34	....
il........	26,461.95	26,166.52	....	$295.43
y........	27,199.12	28,138.40	939.28	....
ıe........	56,022.86	60,661.03	4,638.17	....
Total........	....	....	22,442.57 295.43	295.43 ....
Net gain........	....	....	22,147.14	....

Summary of subsistence operations.

	Profit.	Loss.
Line hotels........	....	$21,944.48
European laborers' messes........	$17,044.15	....
Common laborers' kitchens........	22,147.14	....
Hotel Tivoli........	279.11	....
Washington Hotel........	....	705.65
Total........	39,470.40 22,650.13	22,650.13 ....
Net profit for year........	16,820.27	....

Force by months, department of labor, quarters and subsistence.

Month.	Gold.	Silver.	Total.
July........	169	1,578	1,747
August........	150	1,865	2,015
September........	147	1,780	1,927
October........	153	1,780	1,933
November........	157	1,908	2,065
December........	165	1,930	2,095
January........	167	1,917	2,084
February........	161	1,849	2,010
March........	157	1,912	2,069
April........	169	2,080	2,249
May........	178	2,087	2,265
June........	179	2,231	2,410

Statement of changes made each month in the gold personnel of the force on the Isthmus.

Month.	Employed in United States.	Employed on Isthmus.	Total employments.	Separations.	Increase (+) or decrease (−).
July	276	300	576	414	+162
August	307	306	613	539	+ 74
September	204	235	439	379	+ 60
October	215	381	596	339	+257
November	117	188	305	369	− 64
December	100	270	370	616	−246
January	119	377	496	467	+ 29
February	95	278	373	319	+ 54
March	70	271	341	355	− 14
April	95	240	335	340	− 5
May	118	313	431	389	+ 42
June	112	223	335	301	+ 34
Total	1,828	3,382	5,210	4,827	

Net additions for the year, 383.

During the year the following houses were authorized for construction upon recommendation of this department:

Standard laborers' barracks	15
Standard laborers' kitchens	5
Standard European laborers' mess halls	2
Cooking sheds	2
Hotel help' quarters	1
Storehouses	6
Standard type church and lodge hall	1
Assembly hall	1
Bath houses	4
Range closets	7
Washhouses	6
Combined range closet and bath	1
Type 8 quarters	1
Type 8-A quarters	1
Type 10 quarters	3
Type 14 quarters	56
Type 17 quarters	17
Type 18 quarters	4
Type 20 quarters	2
Type 21 quarters	6
Type 24 quarters	1
Chapel	1

Statement of immigration and emigration through Isthmian ports, by months.

Month.	Immigration.	Emigration.
July	5,426	3,490
August	4,972	3,731
September	5,885	3,610
October	5,485	3,616
November	4,803	3,871
December	4,970	5,264
January	5,077	3,728
February	4,894	3,687
March	5,762	4,111
April	5,681	4,423
May	5,791	4,142
June	7,252	4,569
Total	65,998	48,242

The excess of immigration over emigration was 17,756, practically all of whom were steerage passengers, so that there is a source of labor supply independent of the men brought to the Isthmus by the commission.

Occupants of Isthmian Canal Commission quarters June, 1908.

District.	Gold employees.			West Indians.			Europeans.		
	Men	Women.	Children.	Men.	Women.	Children.	Men.	Women.	Children.
La Boca	182	41	40	204	16	25	186	6	2
Ancon	295	111	79	167	2	5	51	5	13
Corozal	127	30	41	123	3	1	263	1	3
Miraflores	28	2	6	152	2	2	461	4	5
Pedro Miguel	195	57	44	222	27	18	302	8	6
Paraiso	283	90	98	685	202	201	403	16	14
Culebra	555	233	199	790	132	152	420	50	69
Empire	791	215	159	821	161	122	339	45	47
Las Cascadas	224	77	78	435	90	64	406	56	33
Bas Obispo	106	36	12	310	12	14	227	14	16
Matachin	57	9	6	75	15	15	153	3	5
Gorgona	632	166	172	988	86	110	435	18	19
San Pablo	136	10	10	442	10	3	413	1	....
Tabernilla	107	32	38	492	21	23	290	....	....
Bohio	15	9	17	40	30	36	....	....	....
Gatun	302	80	78	1,430	29	20	404	13	17
Cristobal	868	216	129	1,049	268	282	295	....	....
Porto Bello	87	1	....	202	....	....	198	....	....
Total	4,990	1,415	1,206	8,627	1,106	1,093	5,246	240	249

Cost.

Month.	Administration.	Labor agents.	Clerks.	Foremen-janitors.	Subsistence.[a]			Total.
					Stewards-clerks.	Cooks.	Waiters-helpers.	
July	$2,166.67	$1,650.00	$9,890.02	$22,660.23	$4,801.73	$4,636.98	$9,054.58	$54,860.21
August	2,377.77	1,650.00	9,810.00	23,699.71	5,187.24	4,998.37	9,947.40	57,390.69
September	3,430.84	1,650.00	7,920.46	29,795.67	6,220.32	6,110.12	10,255.42	65,382.83
October	2,666.67	1,650.00	8,378.40	30,108.27	5,693.87	5,610.09	10,387.29	64,494.59
November	2,766.67	1,400.00	8,464.92	32,129.28	5,684.39	5,782.39	11,567.27	67,794.92
December	2,766.67	1,400.00	10,691.21	30,961.38	6,091.49	4,526.24	12,305.86	68,742.85
January	2,326.66	1,400.00	10,709.22	30,206.96	6,377.69	4,421.13	13,589.57	69,031.23
February	2,326.67	1,400.00	10,542.50	28,566.18	6,222.24	4,298.38	13,501.80	66,587.77
March	2,326.67	1,400.00	11,371.43	29,133.33	6,947.98	4,790.79	12,514.31	68,484.51
April	2,326.67	1,400.00	12,057.00	32,603.31	7,209.12	5,126.61	12,687.06	73,409.77
May	2,326.67	1,400.00	11,458.28	33,360.94	7,724.90	4,381.88	13,338.59	73,991.26
June	2,326.67	1,400.00	13,459.68	41,074.69	7,969.13	4,736.54	14,207.59	85,174.30
Total	....	....	....	....	76,130.10	59,419.52	143,356.74	815,614.93

[a] Total subsistence, $278,906.36.

Hotel Tivoli.

Month.	Quarters.	Subsistence.	Total.
July	$1,528.90	$1,477.62	$3,006.52
August	1,288.60	1,242.09	2,530.69
September	1,227.49	1,165.00	2,392.49
October	1,162.30	1,458.85	2,621.15
November	1,371.27	1,190.13	2,561.40
December	1,124.30	1,626.12	2,750.42
January	1,626.10	1,159.91	2,786.01
February	1,147.71	1,634.98	2,782.69
March	1,174.96	1,637.77	2,812.73
April	1,023.76	1,458.58	2,482.34
May	1,155.25	1,319.73	2,474.98
June	1,167.75	1,410.18	2,577.93
Total	....	....	31,779.35

NOTE.—The amounts above, under subsistence and Hotel Tivoli, totaling $310,685.71, are charged in the expense of subsistence operations, so that the net pay-roll cost of the operation of the department for the fiscal year was $536,708.57.

APPENDIX K.

REPORT OF HON. JO. C. S. BLACKBURN, MEMBER OF ISTHMIAN CANAL COMMISSION, HEAD OF THE DEPARTMENT OF CIVIL ADMINISTRATION.

ANCON, CANAL ZONE, *July 30, 1908.*

SIR: I have the honor to forward herewith report of the department of civil administration of the commission for the fiscal year ended June 30, 1908:

The department of civil administration of the Canal Commission is the government of the Canal Zone. No changes in the organization of the department have been made during the past fiscal year. It remains as it was described in the last annual report. The name and scope of the department as then described were fixed by the chairman's order of May 9, 1907. Executive approval of that order was given by the President's order signed January 6, 1908, reorganizing the commission, which provided that among the other departments of the commission there should be:

A department of civil administration, charged with the duty of administering the civil government within the Canal Zone.

The executive branch of the department includes the executive office, the divisions of posts, customs and revenues, police and prisons, schools, fire protection, and public works, and the office of the prosecuting attorney. The judicial branch includes the supreme, circuit, and district courts of the Zone.

In addition to the supervision of the work of the divisions of the department, the head of the department also represents the commission in its relations with the Republic of Panama, and with foreign consuls accredited to Panama whose jurisdiction extends to the Canal Zone.

LEGISLATION.

Congressional legislation during the year affecting the Canal Zone includes the provision in the appropriation act of May 27, 1908, respecting the use of local revenues of the Zone, the employer's liability act, and the act providing for the compensation of government employees injured in the performance of duty.

The President promulgated in the course of the year several executive orders having the effect of law in the Canal Zone. Among the most important of these orders are the order of January 9, 1908, extending to the Canal Zone the Chinese-exclusion law of the Republic of Panama, and the order of February 6 providing for trial by jury in all criminal prosecutions in the Canal Zone wherein the penalty of death or imprisonment for life may be inflicted. Previous to the promulgation of this latter order, the law provided that capital cases should be tried before the judge of the circuit in which the crime had been committed, and two lay associates.

The Isthmian Canal Commission, with the approval of the Secretary of War, under authority of the President's order of April 15, 1907, enacted various ordinances relative to sanitation, taxation, and the police power. Among these are ordinances prescribing building regulations for the Canal Zone, providing for the impounding of stray animals, and revising the liquor regulations and the schedule of general taxes and license fees collected in the Zone.

RELATIONS WITH PANAMA.

Almost all the questions discussed with the officials of the Republic of Panama during the year either grew out of the provisions of the canal treaty and subsequent agreements between the United States and Panama, including the authority of the United States to do sanitary work in the cities of Panama and Colon, or arose from the proximity of the Zone and Panama. Some of the questions in the first class are: The removal by the commission of stone for canal purposes from the quarry at Porto Bello in the Republic of Panama, and the purchase of land for that purpose; the organization of the joint commission for the appraisal of private land used for canal purposes; the boundary line between the Zone and Panama; exchange of mails between Panama and the Canal Zone and the use in the Zone of Panama postage stamps; a method of committing insane persons from Panama to the insane asylum of the health department of the commission in the Zone; the sale to employees of the commission and Panama Railroad, through the commissaries of the railroad, of supplies brought into the Zone free of duty; water rates, plumbing regulations, the condition of the water supply; street cleaning and garbage removal, and the opening of new streets in Panama and Colon. Among the questions of the second class, arising from the contiguity of the Zone and Panama, are uniform harbor regulations for the harbors of Panama and the Zone; uniform ordinances in Panama and the Zone requiring dogs to be muzzled, necessary because of an epidemic of hydrophobia; uniform regulations governing public carriages; the exercise by police and other officials of one government of authority in the territory of the other; uniform laws to prohibit the soliciting of labor in Panama and the Zone; work of the Zone fire department in the cities of Panama and Colon; and a census of Panama and Colon.

Among other questions also discussed are: The transfer of old government records from the Zone to Panama; the preservation of a supply of rifles and other munitions of war, the property of Panama, placed in the commission's charge for safe-keeping; the authentication of legal documents originating in Panama or the Canal Zone for use in the other jurisdiction; and the conduct of the presidential and municipal elections in Panama in June and July of this year.

The relations between the commission and Panama were, and continue to be, satisfactory. The officials of the Republic manifested at all times an interest in the work of the commission and a desire to assist in its rapid and economical execution.

Relations with foreign consuls whose jurisdiction extends to the Canal Zone were satisfactory. Almost all the questions discussed with them involved the interests of citizens or subjects of their countries living in the Zone.

DIVISION OF POSTS, CUSTOMS, AND REVENUES.

This division includes the postal, customs, and public land services, the collection of taxes and license fees, and the administration of estates of deceased American employees of the commission.

POSTAL SERVICE.

For the fiscal year the sale of postage stamps amounted to $72,708.67, and there was collected for second-class postage 87 cents, making a total income from postage sales of $72,709.54. The increase over the year previous is $17,905.75, or 32 per cent. The greater part of the mail handled is carried free under government frank. It is estimated that the increase in the total volume of mail handled corresponds with the increase in stamp sales.

At Cristobal during the year there were 838 dispatches of mail, including those made to Colon. There were handled during the year 142,089 registered letters and parcels. Of these, 26,784 were domestic letters, 5,513 domestic parcels, 42,671 foreign letters, 1,068 foreign parcels, 64,310 official letters and parcels registered free, and 1,743 letters and parcels re-registered free. From these figures it will be observed that 45 per cent of the registry business is official, for which no postage or registry fee is collected.

The offices at Ancon and Cristobal handle the foreign registered mail. At Ancon during the year there were 10,121 exchanges handled for Panama and Pacific points, while at Cristobal there were 64,630 exchanges handled for the United States, the West Indies, and Europe.

In November, 1907, sea postal clerks were placed on the Panama Railroad steamers between New York and Colon, greatly facilitating the handling of mail to and from the United States.

One hundred and fifty-three thousand four hundred and fifty-seven money orders were issued during the year for a total of $4,686,684.98, yielding a revenue in fees of $19,309.14. There were paid and repaid for this period orders amounting to $1,051,129.42. The average amount of each order is $30.54. The average monthly money order sales now exceed $400,000.

Of the money orders issued during the year, orders amounting to $3,460,755.25 were payable in the United States and other countries, while orders amounting to $1,225,929.73 were payable in the Canal Zone. The orders payable in the Canal Zone are in a large measure drawn to the order of the purchasers themselves, and represent employees' savings deposited with the government for safe-keeping.

During the year ended June 30, 1907, 82,830 money orders were issued, for the aggregate amount of $2,318,956.34, the fees amounting to $9,832.65. The increase in the money-order business, as compared with the preceding year, is more than 100 per cent.

New buildings erected for post-office purposes at Cristobal, Culebra, and Ancon were completed and occupied during the year.

CUSTOMS SERVICE.

During the past year 182 vessels entered at the port of Ancon, with a total tonnage of 352,590, and 181 vessels cleared, with a tonnage of 352,484. At Cristobal 230 vessels entered, with a tonnage of 455,273, and 233 vessels cleared, with a tonnage of 458,050. The

usual services were rendered seamen and vessels. Under the agreement with Panama no duties or customs fees were collected.

At the port of Ancon 284 Chinese arrived in transit to the Republic of Panama or other countries. Of this number 246 were permitted to disembark, by authority of the secretary of foreign affairs of the Republic of Panama, and 38 were transferred or returned to the port of embarkation.

PUBLIC LAND SERVICE.

At the close of business, June 30, 1908, there were in force 1,081 leases, of which 878 were for building lots, 194 for agricultural land, and 9 for buildings. The area of the agricultural land under lease is 590 hectares, or 1,458 acres. Rent collected during the year amounted to $17,436.76, as against $7,974.78 for the fiscal year ended June 30, 1907—an increase of $9,461.98, or more than 100 per cent.

TAXES AND LICENSE FEES.

During the year there was collected on account of general taxes and licenses the sum of $77,467.47.

There was collected as distillation tax $3,814.94, or about one-half as much as for the year previous. The collections for this tax have steadily decreased since 1905.

Thirty-four licenses were issued for the sale of liquor at retail. The license fee is $1,200 per annum, and the total revenue from this source was $40,800.

Only one company qualified to do business in the Canal Zone under the terms of the executive order of the Secretary of War, dated March 12, 1907, respecting insurance and bonding companies. This company paid the prescribed fees, amounting to $129.02

ADMINISTRATION OF ESTATES.

The collector of revenues is ex officio administrator of estates for the Canal Zone, where decedents were citizens of the United States and employees of the Isthmian Canal Commission or the Panama Railroad and the estate consists entirely of personal property not exceeding in value $500 United States currency.

At the close of business on June 30, 1907, 8 estates remained unsettled, and during the past fiscal year 40 new estates were received. Thirty-two estates were settled, leaving 16 which it has been impossible to settle, or for which proper proofs of heirship have not been received. The money handled during the year on account of administration of estates aggregated $6,025.75.

MISCELLANEOUS COLLECTIONS.

In addition to the collection of Zone revenues this division collects for other departments of the commission various bills from employees and others on account of hospital fees, quarantine charges, subsistence, sales of material, etc. These collections during the year aggregated $22,054.24

The revenues collected by the division during the year aggregated $231,666.87, and all the moneys handled, $4,946,431.84.

DIVISION OF POLICE AND PRISONS.

The chief of police, in addition to being the head of the police force, is also marshal of the supreme and circuit courts, warden of the penitentiary, and coroner of the Zone, and members of the force act as deputy marshals, deputy warden, deputy coroners, etc. In addition to police duty and the duties indicated by these titles, members of the police force perform duty as watchmen of commission property and guards at pay offices and on pay cars and passenger trains. At the end of the year there were in the force a chief, 1 first lieutenant, 1 second lieutenant, 10 sergeants, 18 corporals, 108 first-class policemen, and 93 policemen. The policemen are colored men, in most part natives of the West Indies.

The increased scale of salaries which went into effect August 1, 1907, resulted in considerable improvement in the work of the force, by attracting better men and holding them longer in the service.

Six thousand and seventy-five arrests were made during the year, 5,723 of males and 352 of females, as against 6,236 during the preceding year. Of the persons arrested, 4,731 were subsequently convicted, 4,633 of misdemeanor and 98 of felony. Misdemeanor convicts are confined in jails attached to the various local police stations. Felony convicts are confined in the penitentiary at Culebra. On June 30, 1907, there were 82 felony convicts in the penitentiary. Seventy-two were discharged during the past year. At the end of the year there were 108.

The penitentiary annex has not yet been completed, and congestion at the penitentiary was relieved during the year by the transfer of a part of the convicts to labor camps, for work on the road under construction between Mount Hope and Gatun. Penitentiary convicts were also used in the construction and repair of roads and streets and other public works near Culebra. Misdemeanor convicts were used wherever possible on similar work in the neighborhood of the jails where they were confined. The value of the work done during the year by penitentiary convicts, at 10 cents per hour, the lowest rate of wages paid common labor by the commission, was $14,856.65 United States currency, while the cost of guarding, subsisting, and clothing all such convicts was $20,779.78. Very satisfactory results in economy and efficiency attended the use of prisoners on public work.

One thousand five hundred and forty writs of process in civil cases were served during the year.

One hundred and forty deaths were investigated by the chief of police or other members of the force, acting as coroner or deputy coroners. Of these 34 resulted from drowning, 10 from dynamite explosions, and 54 from railroad accidents.

DIVISION OF SCHOOLS.

The schools opened October 1, 1907, with an enrollment in that month of 1,365 children; 351 in the white and 1,014 in the colored schools. In all 2,867 children were enrolled during the year; 721 in the white and 2,146 in the colored schools. The highest monthly enrollment was in March, when 532 children were enrolled in the white schools and 1,364 in the colored schools. Schools were main-

tained for white children at 11 places, and for colored children at 15 places. New school buildings were completed and occupied during the school year at Ancon, Paraiso, Culebra, Empire (2), Las Cascadas, Bas Obispo, Gatun, Cristobal, and Colon Beach.

DIVISION OF FIRE PROTECTION.

The work of this division includes the operations of paid and volunteer fire companies, maintenance of electric fire-alarm systems, distribution, inspection, and maintenance of hose and fire extinguishers for special protection of commission and railroad buildings, and recommendations respecting construction and arrangement of buildings and location of water mains and hydrants with reference to fire protection.

At the beginning of the year paid companies existed at Cristobal and Ancon. During the year new paid companies were organized and installed at Gorgona, Empire, Culebra, and Ancon.

Each of the new companies consists of 4 men and is provided with a hose wagon equipped with extension ladder, straight-roof ladder, and 1,000 feet of hose. Paid firemen were stationed during the year at Gatun, Las Cascadas, Paraiso, and La Boca, one man at each place.

New volunteer companies were organized during the year at San Pablo, Bas Obispo, and Porto Bello, making a total, with the volunteer companies which already existed at Gatun, Tabernilla, Gorgona (2), Gorgona shops, Las Cascadas, Empire (2), Culebra (2), Paraiso, Pedro Miguel, Corozal, Ancon, and La Boca, of 18, all provided with hose reels and hose.

All volunteer companies were drilled regularly twice a month by members of paid companies where there are such companies, by individual paid firemen where they are stationed, and by firemen detailed from the Cristobal company at all other places. A new building was erected for the volunteers at Tabernilla.

Electric fire-alarm systems were installed during the year at Gorgona, Empire, Culebra, and Ancon. These and the alarm system at Cristobal were inspected and maintained by the electrician and fireman detailed from the Cristobal company.

Eleven thousand six hundred and fifty-nine feet of new hose was received and distributed and 100 couplings were reset on damaged of worn-out hose. Five hundred fire extinguishers were received and distributed, making a total of 1,387 in service at the end of the year. Thirty-one thousand and fifty-five inspections and 231 recharges or fire extinguishers were made. All camps where there are hose connections were provided with small carts equipped with hose in addition to fire extinguishers. All inspections of fire extinguishers, hose, and other equipment and of buildings generally at places where there are paid companies or where individual firemen are stationed were made by them. At other places inspections were made by firemen detailed from the Cristobal company. General inspections were made by the chief and assistant chief.

For the protection of docks at Cristobal and Colon the tug *Cristobal* was equipped with two large fire pumps and a supply of hose, and for the same purpose at La Boca the tug *Bolivar* was equipped with one large pump and a supply of hose.

Eighty-three alarms were responded to during the year. Twelve of them were false alarms, 5 were in Panama territory, and 63 were alarms of fire in government property. The total value of government property involved, including buildings and their contents, as reported by the fire chief, was $1,097,619.46. The total loss of government property as reported was $46,170.50. Forty-five thousand four hundred dollars and fifty cents of the loss resulted from 3 fires, those which destroyed the commission hotel at Empire, a type 14 house at Gorgona, and the Panama Railroad storehouse at Panama.

The fires at Empire and Gorgona occurred before paid companies were established at those places and were fought by volunteers in charge of one regular fireman. The fact that they were confined to the buildings in which they originated is evidence of good work.

The fire at Panama occurred within the limits of that city and was responded to by the paid company at Ancon, who were greatly handicapped in their work by a misunderstanding with the Panama volunteer firemen.

The average government loss at the remaining fires was $12.84. The companies at Cristobal and Ancon responded to alarms in Colon and Panama and cooperated with the firemen of those cities in protecting property there.

DIVISION OF PUBLIC WORKS.

The work of this division includes, in Panama and Colon, the approval of applications of property owners for the connection of their premises with waterworks and sewers, the inspection of plumbing, the keeping of records of water consumed and preparation and collection of bills therefor, and the maintenance of water and sewer systems and street paving; in the Zone, the approval of applications of property owners for water and sewer connections, the inspection of plumbing, the keeping of records of water consumed and preparation of bills therefor, the inspection of water mains and connections to detect leaks and prevent waste, the operation of public markets and slaughterhouses, and recommendations for the construction and repair of roads, trails, water and sewer systems, markets, slaughterhouses, lights, and other public improvements. All original installation and construction work in Panama and Colon, and all construction and repair work on roads, trails, and other public improvements in the Zone is done by the department of construction and engineering.

In Panama there were, on June 30, 1907, 1,023 connections with the water and sewer systems and 93 applications pending. June 30, 1908, there were 1,189 connections and 62 applications pending, an increase of 166 connections during the year, the installation of which was inspected.

Under the contract between the Republic of Panama and the Canal Commission effective July 1, 1907, the water rate in Panama is 30 cents per 1,000 gallons, with a discount of 5 cents if paid within fifteen days from the end of the quarter. The collections at this rate will, it is estimated, provide for the amortization of the cost of the water and sewer systems and paving in fifty years, as contemplated by the canal treaty, together with the maintenance and operation of the water and sewer systems for the same period and the maintenance and repair of the pavements for ten years. The estimated annual amount

necessary to meet these charges is $65,525. The contract provides that Panama shall pay quarterly the difference between one-fourth that amount, $16,400, and the total quarterly collections from private consumers, such payment to cover the consumption of water for public purposes. The total collections from private consumers for the year were $42,568.25, leaving $6,631.75 to be paid by Panama to cover the consumption of water from 133 fire hydrants and 35 public taps, an average annual charge per hydrant and tap of $39.47. As the installation of house connections progressed during the year, private consumption increased. In the last quarter of the year the collections from private consumers aggregated $16,591.75, and there was no charge to be made against Panama. About 86 per cent of the houses in the city are connected with water and sewer mains, practically all those not connected being in parts of the city where sewer mains have not been laid. Estimating the population of Panama at 36,388, the daily per capita consumption of water during the year was 12.98 gallons. The average annual charge per connection was $51.93.

Mains, hydrants, and valves were repaired, meters tested, and once a week sewers and catch basins cleaned. Seventy excavations were made in paving for new connections and repairs to water and sewer mains, and minor repairs were made to paving.

In Colon on June 30, 1907, there were 64 connections with the water and sewer systems, and 66 applications pending. June 30, 1908, there were 318 connections, and 53 applications pending—an increase of 254 connections during the year, the installation of which was inspected. These figures do not include the Canal Commission and Panama Railroad connections.

The contract for the collection of water rates in Colon is similar to that for Panama; the rate at Colon being 50 cents per 1,000 gallons with a discount of 10 cents, and the estimated yearly amount necessary to be collected being $69,850, or $17,500 a quarter. It is also provided in the contract that the rate to be paid by the Canal Commission and the Panama Railroad for water consumed in Colon shall be 30 cents net per 1,000 gallons.

The total collections for water consumed during the year, including Canal Commission and Panama Railroad connections, which amounted to $22,618.97, were $47,852.87, leaving $22,147.13 to be paid by Panama to cover the consumption of water from 74 fire hydrants and 18 public taps—an average annual charge per hydrant and tap of $240.73. Private consumption increased during the year until the fourth quarter, when there was a decrease. About 50 per cent of the houses in the city are connected with water and sewer mains, and reasonable progress is being made in completing connections. Estimating the population of Colon at 14,263, the daily per capita consumption of water during the year, exclusive of that used by the commission and railroad was 53 gallons. The average annual charge per private connection was $119.05. Until all connections are completed it will be impossible to say with more than approximate accuracy whether the present water rates will be sufficient to cover the annual charges.

The conditions in Colon are so different from those in Panama, or in any city in the United States, that comparison is misleading The water has to be pumped into a standpipe, and the sewage has to be pumped to a drainage ditch having tidal gates that regulate the

flow into the sea. This makes the operation of the waterworks and sewer systems very expensive. The town is composed largely of tenement houses, filled chiefly with West Indian laborers who have never before had conveniences of water and sewers, and are careless and wasteful of water. This makes large private bills.

The water and sewer systems and paving were taken over by this division for operation and maintenance September 1, 1907. An additional engine and pump, taken from old French stock, were installed at the sewage sump during the year, and a building was constructed at the pumping plant containing an office, workshop, storehouse, and quarters for employees working there. Maintenance work was done of the same sort as in Panama. Thirty-six excavations in paving were made for water and sewer connections and repairs.

Regulations and rates for the use of water from public systems in the Zone were prepared and published during the year. There were 34 connections with the water systems in the Zone June 30, 1907, and 75 connections June 30, 1908—an increase of 41 during the year, the installation of which was authorized and inspected. Bills amounting to $2,772.37 for water consumed through private connections were prepared and forwarded to the collector of revenues for collection.

Considerable saving of water on the Zone resulted from the detection of leaks and unnecessary waste and the immediate execution of minor repairs by meter inspectors attached to this division. The daily consumption from the reservoirs was watched, and when it seemed unduly large, the inspectors were notified and the cause discovered and removed. Daily reports were made by the inspectors throughout the year.

New public markets were constructed during the year at Pedro Miguel, Paraiso, Culebra, Las Cascadas, and Tabernilla, making, with the markets at Empire, Gorgona, and Cristobal, eight in operation during the year. Public slaughterhouses were operated at Empire and Gorgona.

Recommendations were made and advice furnished respecting other public improvements in the Zone paid for from local funds, described elsewhere in this report.

PROSECUTING ATTORNEY'S OFFICE.

The prosecuting attorney has charge of the prosecution before the courts of offenses against the penal laws of the Zone. The general civil legal business of the commission is handled under the direction of the general counsel in the legal department.

During the year information was filed in the circuit courts by the prosecuting attorney against 366 persons, resulting in 192 convictions.

CANAL ZONE FUNDS.

By the act of March 4, 1907, the use of Zone revenues is authorized for the payment of miscellaneous and contingent expenses of the Zone government, the construction, maintenance, and operation of public works and public improvements, the maintenance of the public schools, and, so far as postal revenues go, the maintenance of the postal service.

The act of May 27, 1908, extended the use of Zone revenues to the maintenance of the administrative districts of the Zone, including the payment of salaries and wages of tax collectors, inspectors, district judges, etc., the maintenance of pauper sick of the Zone in the hospitals of the Canal Commission, and the maintenance of misdemeanor prisoners serving sentence in the jails of the Zone.

At the beginning of the fiscal year there was $144,358.09 on hand in the Zone treasury; $283,906.17 was collected during the year and $183,501.95 was expended, leaving a balance on hand at the end of the year of $244,762.31.

Of the amount expended during the year $47,175.03 was for public works and improvements in the Zone, including construction and maintenance of streets, roads, trails, and bridges, the construction, maintenance, and operation of markets and slaughterhouses, the construction of waterworks and sewers in native villages, garbage and night-soil removal, drainage and street cleaning; $35,749.47 was expended for the maintenance of public schools; $99,673.21 was expended toward the maintenance of the postal service, and $904.24 was expended to cover miscellaneous and contingent expenses. It is probable that, upon the final adjustment of accounts for the year between the Canal Commission and the Zone government, it will be found that additional expenditures are properly chargeable against Zone revenues and that the balance shown on hand at the end of the fiscal year will be reduced.

It is estimated that the revenues of the Zone during the current fiscal year, exclusive of postal receipts, will aggregate approximately $235,000. This amount will be expended approximately as follows:

Maintenance of schools	$96,160
Expenses of district courts	12,350
Expenses of offices of district tax collectors	22,800
Maintenance of pauper sick in commission hospitals	5,475
Maintenance of misdemeanor prisoners	18,000
Maintenance of markets and slaughterhouses	3,600
Construction, repair, maintenance, and operation of roads, trails, bridges, waterworks and sewers, night-soil and garbage removal and street cleaning in native villages, and other miscellaneous public works and improvements	66,615
Miscellaneous and contingent expenses	10,000
Total	235,000

It is estimated that the postal revenues during the current fiscal year will aggregate approximately $90,000. They will be applied toward the maintenance of the postal service.

COURTS.

The supreme court held 17 sessions during the year. It confirmed the decision of the circuit court in 2 criminal and 4 civil cases, reversed the decision in 1 criminal and 2 civil cases, and dismissed 1 criminal and 1 civil case.

In the circuit courts criminal cases were filed against 366 persons (192 of whom were convicted and 56 acquitted). Cases against 94 persons were dismissed and against 24 persons were pending at the end of the year. Twenty-nine civil cases were pending at the beginning of the year, 82 were filed during the year, 65 were disposed of during the year, and 46 were pending at the end of the year.

In the district courts criminal cases against 5,776 persons were filed (4,413 persons were convicted, 310 committed for action by the circuit courts, 736 acquitted, 292 discharged, and cases against 25 persons were pending at the end of the year). Four hundred and thirty-three civil cases were filed, of which 419 were disposed of and 14 were pending at the end of the year.

Attention is called to the statements attached as appendices to this report, which indicate in detail the business transacted throughout the department.

Very respectfully,

Jo. C. S. Blackburn,
Head of Department of Civil Administration.

Lieut. Col. Geo. W. Goethals,
Corps of Engineers, U. S. Army,
Chairman and Chief Engineer,
Isthmian Canal Commission,
Culebra, Canal Zone.

APPENDICES TO REPORT OF THE HEAD OF THE DEPARTMENT OF CIVIL ADMINISTRATION.

Appendix 1.

Table 1.—Statement of sale of surcharged Panama postage stamps.
Table 2.—Statement of registry business.
Table 3.—Statement of mail dispatched to foreign ports and quantity of mail handled by railway mail messengers.
Table 4.—Statement of money order business.
Table 5.—Statement of customs operations.
Table 6.—Consolidated statement of general taxes and licenses collected.
Table 7.—Classified statement of general taxes and licenses by administrative districts.

Appendix 2.

Table 8.—Statement of charges against persons arrested.
Table 9.—Statement showing the nationality of persons arrested.
Table 10.—Statement of crimes committed by persons confined in the penitentiary.
Table 11.—Statement showing occupation of prisoners confined in the penitentiary.
Table 12.—Statement showing the nationality of prisoners confined in the penitentiary.
Table 13.—Statement showing causes of deaths investigated by the coroner.
Table 14.—Statement showing the nationality of persons whose deaths were investigated by the coroner.

Appendix 3.

Table 15.—Statement showing enrollment in the public schools by towns.
Table 16.—Statement showing enrollment and average daily attendance in white and colored schools.
Table 17.—Statement showing enrollment in the public schools by ages.
Table 18.—Statement showing enrollment in the public schools by grades.

Appendix 4.

Table 19.—Statement showing consumption of water, collections made, and bills outstanding for water rents, in the city of Panama.
Table 20.—Statement showing consumption of water, collections made, and bills outstanding for water rents, in the city of Colon.

Appendix 5.

Table 21.—Statement showing receipts and disbursements by appropriations of Canal Zone funds.

Appendix 6.

Table 22.—Statement of business transacted in the supreme court of the Canal Zone.
Table 23.—Statement of business transacted in the first circuit court.
Table 24.—Statement of business transacted in the second circuit court.
Table 25.—Statement of business transacted in the third circuit court.
Table 26.—Statement of business transacted in the district court of the district of Ancon.
Table 27.—Statement of business transacted in the district court of the district of Empire.
Table 28.—Statement of business transacted in the district court of the district of Gorgona.
Table 29.—Statement of business transacted in the district court of the district of Cristobal.

APPENDIX 1.—DEPARTMENT OF REVENUES.

TABLE 1.—*Sale of postage stamps by months during the fiscal year ended June 30, 1908.*

Month.	Value.	Month.	Value.
1907.		1908—Continued.	
July	$4,992.11	March	$6,331.90
August	6,031.22	April	6,299.13
September	5,126.39	May	5,416.40
October	6,904.25	June	5,699.60
November	5,824.02	June (second-class postage)	.87
December	7,271.00	Total	72,709.54
1908.			
January	6,701.00		
February	6,111.05		

TABLE 2.—*Letters and parcels registered by offices during the fiscal year ended June 30, 1908.*

Name of post-office.	Domestic letters registered.	Domestic parcels registered.	Foreign letters registered.	Foreign parcels registered.	Official registered free.	Distribution re-registered free.	Total.
Ancon	2,506	826	5,634	200	9,378	103	18,647
Ancon, Station A	1,196	160	248	87	6,066	117	7,874
Bas Obispo	600	134	1,295	11	2,929	85	5,054
Bohio	262	14	268	5	467	7	1,023
Cristobal	5,638	1,055	8,221	118	6,374	186	21,592
Culebra	2,265	509	3,820	157	2,845	256	9,852
Corozal	405	56	733	46	1,907	55	3,202
Empire	3,190	766	5,781	126	16,313	291	26,467
Gatun	1,123	204	2,861	75	4,163	98	8,524
Gorgona	2,291	527	3,974	47	2,289	69	9,197
Las Cascadas	1,160	246	1,802	20	583	121	3,932
La Boca	1,256	171	1,792	58	2,766	87	6,130
Matachin	175	13	466	6	519	26	1,205
Paraiso	1,097	326	1,384	18	2,339	89	5,253
Pedro Miguel	2,672	324	2,218	80	2,102	18	7,414
San Pablo	334	69	1,050	5	1,843	81	3,382
Tabernilla	614	113	1,124	9	1,427	54	3,341
Total	26,784	5,513	42,671	1,068	64,310	1,743	142,089

TABLE 3.—*Number of dispatches of mail from the exchange office at Cristobal, and number of pouches, sacks, and registered sacks handled by the railway mail messengers by months during fiscal year ended June 30, 1908.*

Month.	Pouches.	Sacks.	Registered sacks.	Total.	Dispatches.
1907.					
July	3,484	707	158	4,349	66
August	3,654	907	211	4,772	61
September	3,675	923	208	4,806	59
October	4,374	1,160	250	5,784	109
November	3,894	1,492	234	5,620	65
December	3,896	1,280	275	5,451	72
1908.					
January	3,895	1,065	261	5,221	66
February	4,516	916	233	5,665	67
March	4,126	944	169	5,239	86
April	3,224	911	175	4,310	73
May	4,544	930	184	5,658	67
June	4,828	782	178	5,788	47
Total	48,110	12,017	2,536	62,663	838

TABLE 4.—*Money-order business by months during the fiscal year ended June 30, 1908.*

Month.	Number of orders issued.	Amount of money-orders issued.			Fees.
		On United States.[a]	On Canal Zone.	Amount.	
1907.					
July	11,565	$281,131.16	$66,738.68	$347,869.84	$1,444.64
August	9,518	241,006.40	70,901.95	311,908.35	1,256.02
September	11,108	254,035.31	78,272.64	332,307.95	1,377.79
October	11,380	276,303.88	75,633.75	351,937.63	1,442.32
November	12,608	287,235.96	94,325.24	381,561.20	1,579.04
December	13,960	308,438.00	99,876.29	408,314.29	1,705.82
1908.					
January	13,451	301,491.34	126,407.91	427,899.25	1,736.19
February	13,395	289,947.77	128,791.80	418,739.57	1,710.85
March	14,206	306,666.63	123,770.53	430,437.16	1,782.15
April	14,672	320,405.58	125,573.90	445,979.48	1,846.05
May	13,425	285,645.07	117,463.07	403,108.14	1,666.30
June	14,169	308,448.15	118,173.97	426,622.12	1,759.97
Total	153,457	3,460,755.25	1,225,929.73	4,686,684.98	19,309.14

[a] Includes foreign money-orders.

Average amount per money-order, $30.54.

Money orders paid and repaid by months during the fiscal year ended June 30, 1908.

Month.	Amount.	Month.	Amount.
1907.		**1908.**	
July	$70,043.24	January	$75,796.49
August	58,090.02	February	81,764.79
September	58,259.39	March	107,359.67
October	69,289.36	April	124,358.94
November	65,497.64	May	123,313.33
December	91,433.53	June	125,943.02
		Total amount issued	1,061,129.42

TABLE 5.—*Customs operations during fiscal year ended June 30, 1908.*

VESSELS ENTERED AND CLEARED AT THE PORT OF ANCON.

Nationality.	Class.	Entered.		Cleared.	
		Number.	Tonnage.	Number.	Tonnage.
American	Steam	64	141,476	63	138,973
Do	Sail	1	620	1	630
British	Steam	65	96,306	64	93,693
Chilean	do	27	45,881	28	51,091
German	do	20	55,513	20	56,512
Norwegian	do	4	9,804	4	9,894
Italian	do	1	2,700	1	2,700
Total		182	352,390	181	352,[illegible]

Number of vessels in port from last year	4
Tonnage in port from last year	7,747
Number of vessels remaining in port at end of year	5
Tonnage remaining in port	7,663
Services to American seamen:	
Seamen discharged	140
Seamen shipped	142
Seamen deserted	76
Seamen deceased	0

Movement of passengers and cargo:	
Cargo arriving, in transit .... tons..	125,132
Cargo departing, in transit .... do....	196,685
Cargo arriving, local .... do....	10,321
Cargo departing, local .... do....	167
Passengers arriving:	
Cabin	3,099
Steerage	2,805
Passengers departing:	
Cabin	2,851
Steerage	2,004
Services to Chinese:	
Chinese arriving	284
Chinese transferred to other ships	34
Chinese returned to port of embarkation	4

VESSELS ENTERED AND CLEARED AT THE PORT OF CRISTOBAL.

Nationality.	Class.	Entered.		Cleared.	
		Number.	Tonnage.	Number.	Tonnage.
American	Steam	62	171,279	62	172,495
Do	Sail	1	305	1	305
British	Steam	73	141,256	74	140,526
Do	Sail	8	2,105	9	2,477
German	Steam	4	6,101	4	6,101
Do	Sail	1	416	1	416
Norwegian	Steam	68	132,378	69	134,297
Panamanian	Sail	4	117	4	117
Swedish	Steam	1	1,194	1	1,194
Colombian	Sail	8	122	8	122
Total		230	455,273	233	458,050

Number of vessels in port from last year	5
Tonnage in port from last year	7,374
Number of vessels remaining in port at end of year	2
Tonnage remaining in port	4,597
Service to American seamen:	
Seamen discharged	60
Seamen shipped	114
Seamen deserted	31
Seamen deceased	2
Movement of passengers and cargo:	
Cargo arriving, in transit .... tons..	51,661
Cargo departing, in transit .... do....	40,448
Cargo arriving, local .... do....	611,141
Cargo departing, local .... do....	16,658
Passengers arriving:	
Cabin	5,688
Steerage	766
Passengers departing:	
Cabin	4,664
Steerage	1,112

TABLE 6.—*General taxes and licenses collected, by months, during the fiscal year ended June 30, 1908.*

Month.	Taxes and licenses.	Month.	Taxes and licenses.
1907.		1908.	
July	$5,772.69	January	$5,164.54
August	5,063.29	February	5,721.31
September	6,161.15	March	8,139.67
October	5,707.51	April	5,887.74
November	4,743.54	May	5,411.51
December	6,136.03	June	13,568.49
		Total	77,467.47

TABLE 4.—*Money-order business by months during the fiscal year* [illegible]

Month.	Number of orders issued.	Amount of money-orders issued: On United States.[a]	On Canal Zone.	[illegible]	[illegible]
1907.					
July	11,[illegible]	$2[illegible]	$6[illegible]	$317,9[illegible]	[illegible]
August	9,5[illegible]	2[illegible]	7[illegible]	[illegible]	[illegible]
September	11,1[illegible]	2[illegible]	7[illegible],272.[illegible]	[illegible]	[illegible]
October	11,[illegible]	2[illegible],[illegible]03.88	7[illegible]	[illegible]	[illegible]
November	12,[illegible]	2[illegible]	94,[illegible]25.24	[illegible]	[illegible]
December	13,[illegible]	[illegible]05,455.00	[illegible]	[illegible]	[illegible]
1908.					
January	13,451	2[illegible]1,49[illegible].[illegible]4	126,407.[illegible]	42[illegible]	
February	13,[illegible]	2[illegible],947.77	12[illegible]	41[illegible]	[illegible]
March	14,2[illegible]	[illegible]	12[illegible],770.[illegible]	4[illegible]	[illegible]
April	14,[illegible]	[illegible],405.58	1[illegible]	447,[illegible]	[illegible]
May	15,425	2[illegible],641.07	[illegible]	4[illegible]	
June	14,1[illegible]	[illegible],418.15	118,[illegible]	[illegible]	[illegible]
Total	153,457	3,[illegible],755.25	1,225,[illegible]	1,[illegible]	[illegible]

[a] Includes foreign money-orders.

Average amount per money-order, $30.54.

Money orders paid and repaid by months during the fiscal year ended June [illegible]

Month.	Amount.	Month.	Amount.
1907.		**1908.**	
July	$70,04[illegible].24	January	[illegible]
August	58,[illegible].02	February	[illegible]
September	58,2[illegible]	March	[illegible]
October	6[illegible],2[illegible]	April	[illegible]
November	6[illegible],[illegible].64	May	[illegible]
December	91,[illegible].23	June	[illegible]
		Total amount issued	[illegible]

TABLE 5.—*Customs operations during fiscal year ended June* [illegible]

VESSELS ENTERED AND CLEARED AT THE PORT OF [illegible].

Nationality.	Class.	Entered: Number.	Tonnage.	Nu[illegible]
American	Steam	64	141,4[illegible]6	6[illegible]
Do	Sail	1	620	[illegible]
British	Steam	6[illegible]	[illegible]	[illegible]
Chilean	do	27	4[illegible]	[illegible]
German	do	20	[illegible]	[illegible]
Norwegian	do	4	[illegible]	
Italian	do	1	[illegible]	
Total		182	[illegible]	

Number of vessels in port from last year ....

Tonnage in port from last year ....

Number of vessels remaining in port at end of year ....

Tonnage remaining in port ....

Services to American seamen:

- Seamen discharged ....
- Seamen shipped ....
- Seamen deserted ....
- Seamen deceased ....

APPENDIX 2.—CRIMINAL STATISTICS—Continued.

TABLE 8. *Charges against persons arrested during the fiscal year ended June 30, 1908*—Continued.

Charge.	Male.	Female.	Total.
[illegible]	112		112
[illegible]	127	5	132
[illegible] other than mar- [illegible]	8		8
[illegible]	40		40
[illegible]	29		29
[illegible]	37	6	43
[illegible]	17		17
[illegible]	1		1
[illegible] States	1		1
[illegible] disorderly	684	9	693
[illegible]	161	3	164
[illegible]	1		1
[illegible] lascivious cohabi- [illegible]	82	49	131
[illegible]	51	2	53
[illegible] (unclassified)	61	2	63
[illegible]	14		14
[illegible] children	1		1
[illegible]	8		8
[illegible] indecent lan- [illegible]	38	8	46
[illegible] exhibi- [illegible]	1		1
[illegible] railroad tracks	1		1
[illegible] under false [illegible]	7		7
Perjury	5		[illegible]
Petit larceny	286	16	[illegible]
Practicing medicine without license	6		[illegible]
Prostitution		7	[illegible]
Public nuisance	3		[illegible]
Rape	5		[illegible]
Receiving bribe	1		[illegible]
Receiving stolen property	13		[illegible]
Refusing to assist officer	1		[illegible]
Resisting arrest	12		[illegible]
Robbery	7		[illegible]
Seduction	3		[illegible]
Slander	1	1	[illegible]
Stowaway aboard ship	2		[illegible]
Threats to commit a crime	18	1	[illegible]
Trespass	342	8	[illegible]
Vagrancy	234		[illegible]
Violating building ordinance	8	4	[illegible]
Violating liquor regulations	31	1	[illegible]
Violating lottery law	4		[illegible]
Violating quarantine law	1		[illegible]
Violating sanitary regulations	614	36	[illegible]
Violating tax ordinance	111	2	[illegible]
Violating water law	10		[illegible]
Total	5,723	352	6,0[illegible]

TABLE 9. —*Nationality of persons arrested during the fiscal year ended June 30, 1908*

Country.	Number.
[illegible]	2
[illegible]	1
[illegible]	120
[illegible]	2
[illegible]	5
[illegible]	10
[illegible]	1,132
[illegible]	2
[illegible]	3
[illegible]	1
[illegible]	1
[illegible]	5
[illegible]	7
[illegible]	65
[illegible]	87
[illegible]	310
[illegible]	15
[illegible]	24
[illegible]	23
[illegible]	6
[illegible]	18
[illegible]	2
[illegible]	1
[illegible]	2
[illegible]	7
[illegible]	1
[illegible]	75
[illegible]	4
[illegible]	36
[illegible]	79
[illegible]	55
[illegible]	1
[illegible]	57
[illegible]	42
[illegible]	115
[illegible]	1
[illegible]	14
[illegible]	5
[illegible]	3
India	[illegible]
Ireland	[illegible]
Italy	[illegible]
Jamaica	[illegible]
Japan	[illegible]
Liberia	[illegible]
Martinique	[illegible]
Mexico	[illegible]
Montserrat	[illegible]
Nassau	[illegible]
Nevis	[illegible]
Nicaragua	[illegible]
Norway	[illegible]
Panama	[illegible]
Peru	[illegible]
Porto Rico	[illegible]
Portugal	[illegible]
Roumania	[illegible]
Russia	[illegible]
San Salvador	[illegible]
Scotland	[illegible]
Spain	77
St. Croix	[illegible]
St. Kitts	[illegible]
St. Lucia	18
St. Martin	[illegible]
St. Thomas	[illegible]
St. Vincent	[illegible]
Sweden	[illegible]
Switzerland	[illegible]
Syria	[illegible]
Trinidad	[illegible]
Turkey	[illegible]
Turk Islands	[illegible]
United States	[illegible]
Venezuela	[illegible]
Wales	[illegible]
Total	6,07[illegible]

TABLE 7.—*General taxes and licenses, by administrative districts, collected during the fiscal year ended June 30, 1908.*

	District.				Total.
	Ancon.	Cristobal.	Empire.	Gorgona.	
Aerated-waters licenses	$654.00	$1,116.40	$2,850.80	$2,067.80	$6,689.00
Billiard licenses			140.00	36.00	176.00
Bowling-alley licenses			70.00		70.00
Boarding-house licenses		22.00	12.00	1.00	35.00
Charcoal permits	80.70	5.40	399.92	57.00	543.02
Cab and coach licenses		583.75	1.25		585.00
Cart licenses		129.80	125.20	21.20	276.20
Confiscated-property sales		17.00		16.05	33.05
Cocoanut sales		175.50			175.50
Dance, public, permits		30.00	212.50	5.00	247.50
Dog licenses	21.00	28.50	166.50	166.00	382.00
Drug tax		12.20	43.50	11.00	66.70
Firearm permits	1.00	14.00	22.00		37.00
Firewood permits	43.25		52.25	3.00	98.50
Fortune-teller license		1.00			1.00
Hotel licenses			9.00		9.00
Huckster licenses	45.00	56.80	99.00	19.40	220.20
Imported-meat tax	410.45	194.13	395.90	7.52	1,008.00
Lime and shell permits	20.00				20.00
Merchandise tax	1,653.50	701.55	5,101.78	4,500.90	11,957.73
Miscellaneous collections	1.00	16.00	106.06	411.90	534.96
Palmistry licenses		2.00	2.00		4.00
Peddling licenses	647.50	1,396.00	3,330.50	1,845.00	7,219.00
Poll tax	1,310.00	799.60	654.40	408.00	3,172.00
Pound fees		124.50	4.00		128.50
Property, public, sales		72.50		3.00	75.50
Public entertainment licenses	20.00	66.00	270.00	325.00	681.00
Real estate tax	4,586.92	1,851.08	4,666.50	913.70	12,018.20
Restaurant and lunch-counter licenses	195.00	252.00	613.80	290.90	1,351.70
Market rentals	96.00	2,036.60	2,035.64	1,566.00	5,734.24
Water rents	644.10	172.40	1,336.90	618.97	2,772.37
Slaughter tax	119.50	1,549.50	7,954.00	3,826.00	13,449.00
Tobacco tax	770.00	1,247.80	3,480.00	2,198.80	7,696.60
Total	11,318.92	12,674.01	34,155.40	19,319.14	77,467.47

APPENDIX 2.—CRIMINAL STATISTICS.

TABLE 8.—*Charges against persons arrested during the fiscal year ended June 30, 1908.*

Charge.	Male.	Female.	Total.
Abduction	1		1
Accessory to rape		1	1
Adultery	6	5	11
Allowing animals at large	11		11
Arson	1		1
Assault	365	25	390
Assault and battery	184	5	189
Assaulting an officer	1		1
Assault with deadly weapon	24		24
Attempt at burglary	3		3
Attempt at rape	4		4
Attempt to assault with deadly weapon	2		2
Attempt to commit burglary	2		2
Attempt to commit crime against nature	1		1
Attempt to defraud	4		4
Attempt to kill	4		4
Attempt to pass forged instrument	1		1
Attempt to receive money under false pretenses	2		2
Attempt to suborn witnesses	1		1
Battery	5		5
Bigamy	1		1
Bringing stolen property into Zone territory	1		1
Burglary	29		29
Buying stolen goods	2		2
Carrying firearms without license	17		17
Concealed weapons	59		59
Conducting disorderly house	5	4	9
Conducting gambling house	1		1
Conducting public dance without license	2		2
Conspiracy	9		9
Contempt of court	36		36
Crime against nature	7		7
Criminal libel	2		2
Cruelty to animals	23		23
Cruelty to children	3	3	6
Defrauding United States Government	1		1
Deportation	12	1	13
Desertion from ship	4		4
Desertion from U. S. Marine Corps	10		10
Destroying public property	1		1
Discharging firearms	8	1	9
Disorderly conduct	1,114	92	1,206
Disturbing the peace	286	46	332
Embezzlement	50	1	51
Escaping from jail	1		1
Extortion	2		2
Extradition	12		12
False imprisonment	1		1
False representation	7		7
False weights	1		1
Fighting	148	7	155
Forgery	12		12
Fraud	34	1	35

APPENDIX 2.—CRIMINAL STATISTICS—Continued.

TABLE 8.—*Charges against persons arrested during the fiscal year ended June 30, 1908*—Continued.

Charge.	Male.	Female.	Total.	Charge.	Male.	Female.	Total.
Gambling	112	......	112	Perjury	5	......	5
Grand larceny	127	5	132	Petit larceny	286	16	302
Homicide (other than murder)	8	......	8	Practicing medicine without license	6	......	6
Inciting riot	40	......	40	Prostitution	......	7	7
Indecent exposure	29	......	29	Public nuisance	3	......	3
Insanity	37	6	43	Rape	5	......	5
Interfering with an officer	17	......	17	Receiving bribe	1	......	1
Interfering with prisoner	1	......	1	Receiving stolen property	13	......	13
Interfering with United States mails	1	......	1	Refusing to assist officer	1	......	1
Intoxicated and disorderly	684	9	693	Resisting arrest	12	......	12
Intoxication	161	3	164	Robbery	7	......	7
Kidnaping	1	......	1	Seduction	3	......	3
Lewd and lascivious cohabitation	82	49	131	Slander	1	1	2
Malicious mischief	51	2	53	Stowaway aboard ship	2	......	2
Miscellaneous (unclassified)	61	2	63	Threats to commit a crime	18	1	19
Murder	14	......	14	Trespass	342	8	350
Nonsupport of children	1	......	1	Vagrancy	234	......	234
Nonsupport of wife	8	......	8	Violating building ordinance	8	4	12
Obscene and indecent language	38	8	46	Violating liquor regulations	31	1	32
Obscene literature, exhibition of, for sale	1	......	1	Violating lottery law	4	......	4
Obstructing railroad tracks	1	......	1	Violating quarantine law	1	......	1
Obtaining money under false pretenses	7	......	7	Violating sanitary regulations	614	36	650
				Violating tax ordinance	111	2	113
				Violating water law	10	......	10
				Total	5,723	352	6,075

TABLE 9.—*Nationality of persons arrested during the fiscal year ended June 30, 1908.*

Country.	Number.	Country.	Number.
Abyssinia	2	India	5
Algeria	1	Ireland	43
Antigua	120	Italy	132
Argentina	2	Jamaica	939
Australia	5	Japan	2
Austria	10	Liberia	1
Barbados	1,132	Martinique	327
Belgium	2	Mexico	20
Bermuda	3	Montserrat	17
Bohemia	1	Nassau	9
Brazil	1	Nevis	4
British Guiana	5	Nicaragua	6
Canada	7	Norway	16
Chile	65	Panama	266
China	87	Peru	34
Colombia	310	Porto Rico	5
Costa Rica	15	Portugal	10
Cuba	24	Roumania	1
Demarara	23	Russia	12
Denmark	6	San Salvador	7
Dominica	18	Scotland	22
Dutch Guiana	2	Spain	775
Dutch West Indies	1	St. Croix	1
East Indies	2	St. Kitts	30
Ecuador	7	St. Lucia	181
Egypt	1	St. Martin	1
England	75	St. Thomas	1
Finland	4	St. Vincent	14
Fortune Island	36	Sweden	15
France	79	Switzerland	2
Germany	55	Syria	28
German South Africa	1	Trinidad	124
Greece	57	Turkey	18
Grenada	42	Turk Islands	1
Guadaloupe	115	United States	650
Guatemala	1	Venezuela	16
Haiti	14	Wales	1
Holland	5		
Hondurus	3	Total	6,075

TABLE 10.—*Crimes committed by prisoners confined in the penitentiary June 30, 1908.*

Crime.	Number.	Crime.	Number.
Adultery	2	Horse stealing	1
Assault with deadly weapon	8	Larceny	9
Assault with intent to kill	2	Murder in first degree	4
Attempt to commit crime against nature	2	Murder in second degree	1
Burglary	11	Obstructing railroad tracks	1
Conspiracy	4	Passing forged pay receipt	1
Crime against nature	6	Rape	[illegible]
Embezzlement	5	Robbery	5
Forgery	9	Voluntary manslaughter	1
Grand larceny	33	Total	106

TABLE 11.—*Occupation of prisoners confined in the penitentiary June 30, 1908.*

Occupation.	Number.	Occupation.	Number.
Blacksmiths	2	No occupation	1
Bookkeeper	1	Oiler	1
Carpenters	5	Painters	2
Clerks	3	Purser	1
Cooks	2	Sailors	8
Domestic	1	Salesman	1
Driller	1	Shoemaker	1
Farmer	1	Switchman	1
Firemen	2	Tailors	2
Foreman	1	Timekeeper	1
Janitors	2	Watchman	1
Jeweler	1		
Laborers	64	Total	108
Machinists	2		

TABLE 12.—*Nationality of prisoners confined in the penitentiary June 30, 1908.*

Nationality.	Number.	Nationality.	Number.
Americans	7	Haitian	1
Antiguan	1	Hondurian	1
Barbadians	28	Italian	1
Bermudian	1	Jamaicans	10
Chileans	7	Martiniquans	7
Colombians	7	Mexican	1
Costa Rican	1	Panamanians	3
Cuban	1	Peruvians	3
Dane	1	Portuguese	1
Dominicans	2	Scotchman	1
Dutch Guianian	1	Spaniards	8
Ecuadorian	1	St. Kitts	1
Egyptian	1	St. Lucians	2
Fortune Islander	1	Trinidadians	4
Frenchmen	2		
French Guianian	1	Total	106
Guadaloupan	1		

TABLE 13.—*Causes of deaths investigated by coroner during fiscal year ended June 30, 1908.*

Cause of death.	Number.	Cause of death.	Number.
Accidental drowning	34	Mangled by machinery	1
Accidental shooting	2	Murdered	3
Accidental traumatism	4	Neck broken	2
Caving in of earth bank	1	Pneumonia	1
Dynamite explosion	10	Pulmonary tuberculosis	1
Electricity	1	Railroad accidents	54
Falling from railroad bridge	1	Shot	1
Gunshot wound	1	Skull fractured	1
Heart disease	1	Struck by lightning	3
Hemorrhage	2	Suicide	4
Homicide	3	Suspected homicide	1
Inflammation of the stomach	1	Syncope	1
Justifiable homicide	1		
Killed by slide of rock	1	Total	138
Malarial fever	2		

TABLE 14.—*Nationality of persons whose death was investigated by the coroner during the fiscal year ended June 30, 1908.*

Country.	Number.	Country.	Number.
Antigua	3	Martinique	9
Bahama	1	Mexico	2
Barbados	18	Montserrat	1
China	2	Panama	9
Colombia	8	Scotland	1
Dominica	1	Spain	25
England	1	St. Lucia	3
France	1	St. Thomas	1
Greece	1	United States	14
Grenada	1	Unknown	6
Italy	3		
Jamaica	27	Total	138

APPENDIX 3.—SCHOOL STATISTICS.

TABLE 15.—*Enrollment during the year, by towns.*

Location.	White schools.			Colored schools.		
	Males.	Females.	Total.	Males.	Females.	Total.
Ancon	38	35	73			
Bohio				56	46	102
Colon Beach	37	34	71			
Cristobal	73	70	143	157	133	290
Cruces				46	25	71
Culebra	50	50	100	71	135	206
Empire	40	34	74	72	76	148
Gatun	22	20	42	33	39	72
Gorgona	31	53	84	82	96	178
La Boca	19	5	24	30	31	61
Las Cascadas	20	23	43			
Las Savanas				26	19	45
Matachin				69	126	195
Mount Hope				110	120	230
Paraiso	24	18	42	87	121	208
Pedro Miguel	16	9	25			
Pleya de Flor				60	74	134
Tabernilla				39	42	81
San Pablo				73	52	125
Total	370	351	721	1,011	1,135	2,146

TABLE 16.—*Enrollment and average daily attendance in white and colored schools, by months.*

Month.	Enrollment.							Average daily attendance.			Percentage of attendance.
	White.		Colored.		Total.		Total enrollment.	White.	Colored.	Total.	
	Male.	Female.	Male.	Female.	White.	Colored.					
1907.											*Per cent.*
October	182	169	522	492	351	1,014	1,365	243	637	880	64.46
November	197	190	575	517	387	1,092	1,479	311	678	989	66.86
December	207	191	543	524	398	1,067	1,465	353	697	1,050	71.67
1908.											
January	244	224	587	564	468	1,151	1,619	403	795	1,198	73.99
February	265	252	654	640	517	1,294	1,811	458	855	1,313	72.50
March	277	255	672	692	532	1,364	1,896	461	891	1,352	71.30
April	273	260	656	673	533	1,329	1,862	466	853	1,319	70.30
May	252	246	665	677	498	1,342	1,840	405	711	1,116	60.65
June	227	233	646	610	460	1,256	1,716	366	775	1,141	66.49
Monthly average	224	224	613	576	460	1,212	1,672	385	765	1,150	68.77

TABLE 20.—*Consumption of water, collections made, and bills outstanding for water rents in the city of Colon for fiscal year ended June 30, 1908.*

[Estimated population, 14,263; 92 hydrants and taps.]

Quarter ending—	Private consumers, not including Panama Railroad or Isthmian Canal Commission.	Private, not including Panama Railroad or Isthmian Canal Commission.	Consumption per quarter.				
			Panama Railroad reservation.	Isthmian Canal Commission Hospital and Quarantine Station.	Hydrant and taps.	Total.	Average daily consumption.
		Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
September 30, 1907	126	8,579,856	11,247,510	5,521,063	44,474,251	69,822,680	758,943
December 31, 1907	184	14,268,154	13,561,000	6,448,094	49,143,012	83,420,260	906,742
March 31, 1908	235	20,230,237	12,885,737	7,294,208	24,559,412	64,969,594	713,951
June 30, 1908	299	19,183,500	12,374,200	6,064,100	22,846,052	60,467,852	664,482
Total for year	....	62,261,747	50,068,447	25,327,465	141,022,727	278,680,386	[a] 761,029

Quarter ending—	Amount collected from private consumers.	Amount collected from Panama Railroad and Isthmian Canal Commission.	Amount to be collected from Panama Government.	Total revenue as per agreement.	Average consumption per private connection per quarter.	Average private quarterly bill.	Cost per hydrant and public tap per quarter
					Gallons.		
September 30, 1907	$3,395.48	$5,030.57	[b] $9,073.95	$17,500.00	68,094	$26.15	$98.63
December 31, 1907	5,948.27	6,002.70	[b] 5,549.03	17,500.00	77,544	32.32	60.32
March 31, 1908	8,166.75	6,054.00	[b] 3,279.25	17,500.00	87,150	34.75	35.64
June 30, 1908	[c] 7,723.40	5,531.70	[b] 4,244.90	17,500.00	64,158	25.83	46.14
Total for year	25,233.90	22,618.97	22,147.13	70,000.00	296,946	119.05	240.73

[a] Daily average [b] Bills outstanding. [c] Net amount of bills.

APPENDIX 5.—CANAL ZONE FUNDS.

TABLE 21.—*Receipts and disbursements by appropriations.*

	March 4, 1907, to June 30, 1907.			
	On hand March 4, 1907.	Receipts.	Disbursements.	Balances June 30, 1907.
Canal Zone funds prior to March 4, 1907	$40,069.94	$1,658.10	$6,959.56	$34,768.48
Municipal funds	80,439.74	300.00	10,544.84	70,194.90
Miscellaneous and contingent	....	10,000.00	20.00	9,980.00
Schools and public improvements	....	32,341.29	....	14,243.13
Schools	....	....	7,314.10	....
Public improvements	....	....	10,784.06	....
Postal receipts	....	26,171.58	11,000.00	15,171.58
Total	120,509.68	70,470.97	46,622.56	144,358.09

APPENDIX 5.—CANAL ZONE FUNDS—Continued.

TABLE 21.—*Receipts and disbursements by appropriations*—Continued.

	July 1, 1907, to June 30, 1908.			
	Balances July 1, 1907.	Receipts.	Disbursements.	Balance June 3[illegible] 1908.
Miscellaneous and contingent	$756.63			$75[illegible]
1908	9,980.00		$904.24	9,07[illegible]
1909		$10,000.00		10,00[illegible]
Schools and public improvements	104,206.75	52.58		98,58[illegible]
Schools			5,298.65	
Public improvements			374.76	
Schools and public improvements, 1908	14,243.13	170,892.23		107,88[illegible]
Schools			30,450.82	
Public improvements			46,800.27	
Schools and public improvements, 1909		10,942.73		10,94[illegible]
Postal receipts:				
1908	15,171.58	84,501.63	99,673.21	
1909		7,517.05		7,517
Total	144,356.09	283,906.17	183,501.95	244,76[illegible]

APPENDIX 6.—BUSINESS TRANSACTED IN THE COURTS OF THE CANAL ZONE DURI[NG] THE FISCAL YEAR ENDED JUNE 30, 1908.

TABLE 22.—*Supreme court.*

	Criminal cases.	Civil cases.		Criminal cases.	Civil cases.
Pending July 1, 1907	1		Reversed	1	
Filed during year	5	7	Dismissed	1	
Affirmed	2	4	Pending June 30, 1908	2	

Number of sessions of court

Number of attorneys admitted

TABLE 23.—*First circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Collections.	
					Fines.	Costs.
1907.						
Cases pending July 1	5					
July	7	1		7		
August	9	3	2	5		
September	7	5		1	$398.00	$7.25
October	8	9		1	163.00	
November	5	1		1		
December	6	3	3			
1908.						
January	4	2	1	3		
February	9	3	1	2		
March	8	3	2	3	30.00	
April	5	4	1	4	100.00	
May	7	3		1	30.00	
June	8	5		3		
Total	88	42	10	31	721.00	7.25

Cases pending June 30, 1908, 5.
Forfeited bail, $100.

CIVIL CASES.

Cases pending July 1, 1907	3
Cases filed	3
Cases settled	5
Cases pending June 30, 1908	1
Costs	$96.20

TABLE 24.—*Second circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Collections.	
					Fines.	Costs.
1907.						
Cases pending July 1	4					
July	11	4		6	$47.00	
August	11	3	2	5	25.00	
September	9	4		4		
October	10	7	2	5	165.00	$18.75
November	3	2		1		
December	25	9	2	4	190.05	20.30
1908.						
January	24	11	3	1	196.00	15.90
February	24	16	8	8	215.00	44.60
March	22	9	5	2	107.00	15.75
April	16	11	7	3	100.00	22.10
May	23	13	5	3	80.00	26.50
June	23	16	3	8	75.00	13.50
Total	205	105	37	50	1,200.05	177.40

Cases pending June 30, 1908, 13.
Forfeited bail, $75.

CIVIL CASES.

Cases pending July 1, 1907	16
Cases filed	54
Cases settled	38
Cases pending June 30, 1908	32
Costs	$826.58

TABLE 25.—*Third circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Collections.	
					Fines.	Costs.
1907.						
Cases pending July 1	2					
July	3	1				
August	5	3		1	$175.00	$11.05
September	5	1	2	4		
October	5	2	1	2		
November	5	2		1	10.00	6.00
December	4	3			25.00	5.70
1908.						
January	11	5			75.00	17.50
February	7	11		2	225.00	29.35
March	7	2	2			
April	9	9	1	1		
May	6	5	2	2	44.00	14.50
June	4	1	1			9.00
Total	73	45	9	13	554.00	93.50

Cases pending June 30, 1908, 6.
Forfeited bail, $225.

CIVIL CASES.

Cases pending July 1, 1907	10
Cases filed	25
Cases settled	22
Cases pending June 30, 1908	13
Costs	$201.14

TABLE 26.—*District court, district of Ancon.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Committed to circuit court.	Dismissed.	Collections.	
						Fines.	Costs.
1907.							
July	54	54				$147.00	$71.25
August	80	80				304.00	121.05
September	87	43	1	18	25	177.00	91.50
October	81	56		9	13	446.00	102.50
November	61	44		5	9	164.00	67.20
December	84	52	13	9	7	359.00	88.30
1908.							
January	59	44	11	3		415.00	75.50
February	71	47	12	9		616.50	105.05
March	73	56	11	6	3	645.00	117.95
April	90	76	7	7		404.50	103.25
May	49	41	4	4		552.00	102.30
June	55	41	8	4		391.00	61.05
Total	844	634	67	74	57	4,621.00	1,106.90

Bail forfeited, $50.

CIVIL CASES.

Cases pending July 1, 1907	1
Cases filed	31
Cases settled	29
Cases pending June 30, 1908	3
Costs	$37.10

TABLE 27.—*District court, district of Empire.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Committed to circuit court.	Dismissed.	Collections.	
						Fines.	Costs.
1907.							
July	152	150	2			$834.00	$276.90
August	153	153				1,183.70	292.55
September	153	122	21	3	2	1,055.00	231.00
October	117	103	16	4		891.00	200.40
November	81	70	12	1		506.00	137.30
December	169	128	14	19	7	847.00	140.50
1908.							
January	174	139	12	20	2	877.00	195.00
February	160	131	16	8	6	696.50	178.00
March	185	152	15	9	3	697.00	227.50
April	198	150	16	12	24	720.00	182.00
May	226	151	46	16	9	665.00	120.70
June	178	139	21	9	8	290.50	92.20
Total	1,946	1,588	191	101	61	9,262.70	2,274.05

Bail forfeited, $104.70.

CIVIL CASES.

Cases pending July 1, 1907	0
Cases filed	219
Cases settled	212
Cases pending June 30, 1908	7
Costs	$450.40

TABLE 28.—*District court, district of Gorgona.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Committed to circuit court.	Collections.	
						Fines.	Costs.
1907.							
July	94	86	7	....	1	$623.30	$214.00
August	62	62	....	....	....	300.30	105.30
September	85	56	13	4	16	221.30	56.30
October	83	53	14	6	3	255.00	61.00
November	102	73	15	11	3	344.30	65.95
December	67	44	13	2	10	335.00	33.75
1908.							
January	146	114	13	4	15	658.00	76.65
February	137	88	13	12	22	300.00	52.30
March	167	108	11	16	15	457.30	53.00
April	160	130	22	3	14	445.00	166.30
May	158	136	12	6	14	319.00	139.00
June	138	96	13	12	12	604.30	144.30
Total	1,359	990	162	77	136	5,155.30	1,158.25

Bail forfeited, $27.

CIVIL CASES.

Cases pending July 1, 1907	0
Cases filed	131
Cases settled	127
Cases pending June 30, 1908	4
Costs	$218.87

TABLE 29. *District court, district of Cristobal.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Committed to circuit court.	Dismissed.	Collections.	
						Fines.	Costs.
1907.							
July	140	103	30	1	8	$493.50	$174.45
August	142	98	38	4	3	404.70	128.80
September	123	82	40	3	1	410.00	127.50
October	105	90	13	1	....	491.50	114.50
November	111	90	17	3	1	501.00	140.75
December	116	89	17	4	8	236.75	79.60
1908.							
January	129	91	13	8	7	333.00	113.75
February	118	93	17	6	3	384.00	127.75
March	134	101	20	7	6	412.50	114.00
April	132	86	37	3	6	302.50	123.25
May	130	102	24	7	2	304.00	126.00
June	245	109	32	9	3	759.00	203.55
Total	1,627	1,201	317	58	48	5,032.45	1,573.90

Bail forfeited, $140.70.

CIVIL CASES.

Cases pending July 1, 1907	0
Cases filed	51
Cases settled	51
Cases pending June 30, 1908	0
Costs	$115.65

The senior district judge sits during the absence of the regular district judges and when none is absent holds court at Culebra to expedite the disp
the district of Empire. During the year he tried 1,165 criminal
265 at Empire, 126 at Gorgona, and 765 at Cristobal) and 28 civil
the totals for the districts in which they were heard.

FIRE STATION, CRISTOBAL.

PLATE 184.

FIRE STATION, GATUN.

POST-OFFICE, LAS CASCADAS.

THE MARKET, CULEBRA.

THE PENITENTIARY, CULEBRA, JUNE, 1908.

CULEBRA SCHOOL HOUSE, BEFORE RECONSTRUCTION.

CULEBRA SCHOOL HOUSE, AFTER RECONSTRUCTION.

PLATE 190.

POLICE STATION, EMPIRE.

PLATE 191.

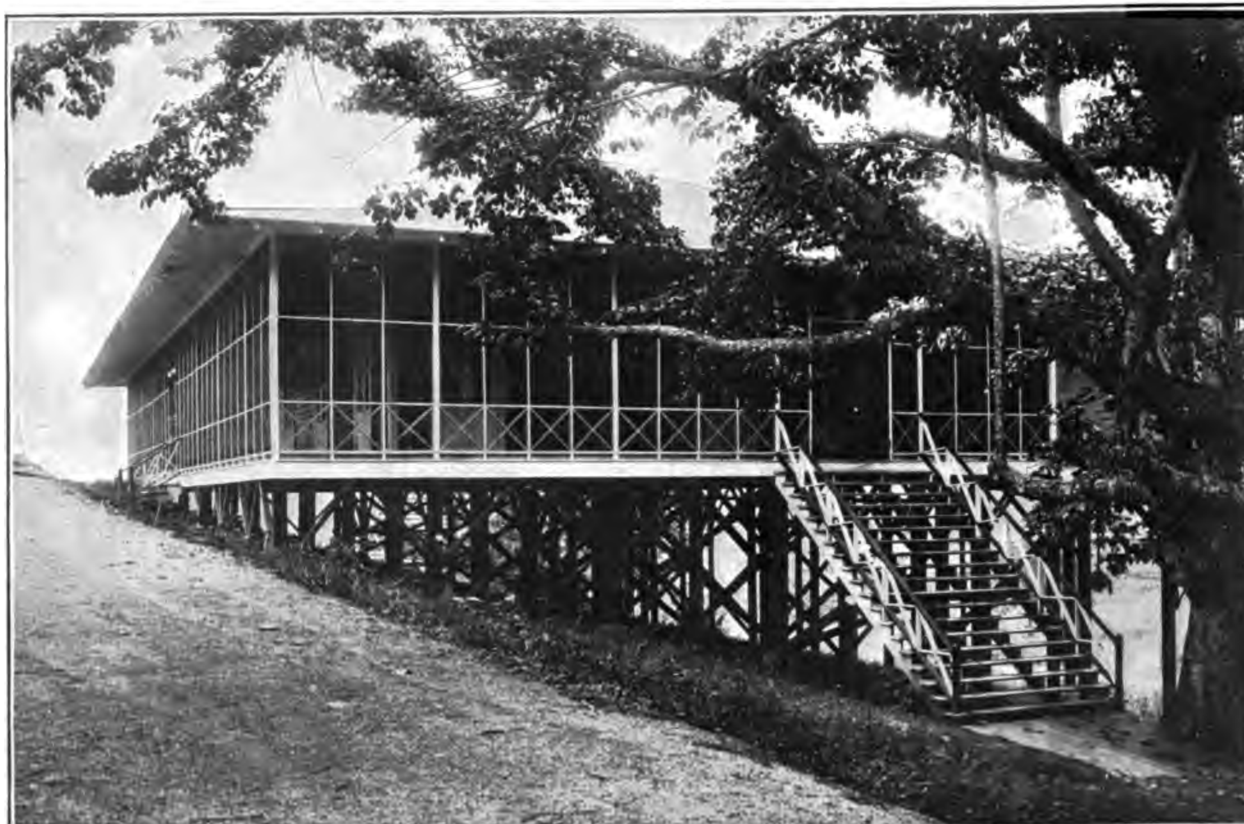
COURT-HOUSE, EMPIRE.

PLATE 192.

POST-OFFICE, ANCON.

PLATE 193.

POLICE STATION, ANCON



PUBLIC SCHOOL HOUSE, ANCON.

APPENDIX L.

REPORT OF COL. W. C. GORGAS, MEDICAL CORPS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, HEAD OF THE DEPARTMENT OF SANITATION.

ANCON, CANAL ZONE, *July 31, 1908*.

SIR: I herewith forward annual report for the fiscal year 1907–8. The conditions during the year have been good, and the report shows a gratifying improvement in the health conditions of the force over that of the preceding year.

Our white force averaged during the year 12,058 men, who had death rate of 15.34 per thousand; last year we averaged 7,727 whites with a death rate of 15.93. About one-third of the deaths among the whites were due to accidents and violence of various kinds The death rate from disease was about 10 per thousand.

We averaged during the year for negro employees 30,999 men, among whom we had 604 deaths, giving us an annual death rate of 19.48 per thousand. The preceding year we averaged 24,587 negro employees, among whom we had 1,152 deaths, giving us an annual rate of 45.94 per thousand. The death rate among our negro employees was therefore less than half what it was as compared with the preceding fiscal year. This I think is due to the subsidence of the epidemic of pneumonia, which was occurring at that time among the negro employees, and also to the steady improvement that has taken place in their housing, feeding, and general sanitary conditions.

Taking our total force, we averaged during the year 43,057 employees, among whom we had 789 deaths, giving us a death rate of 18.32 per thousand. During the preceding fiscal year we averaged 32,324 employees, with 1,272 deaths, giving us a rate of 39.41 per thousand; that is, the death rate in our whole force was less than half of that of the preceding fiscal year. This decrease in the deaths took place almost entirely among our negro employees.

We had during the year a total population of 112,002, among whom we had 3,100 deaths, giving us an annual death rate of 27.67 per thousand. During the preceding year our total population averaged 87,215, among whom we had 3,672 deaths, giving us a rate of 42.08 per thousand, showing a very gratifying decrease in the death rate of our total population.

During the year we had an average of 5,035 white American employees, among whom we had 41 deaths, giving us a rate of 8.14 per thousand among this class of employees. Of these 41 deaths, 27 were due to disease and 14 to violence and causes other than disease. This would give us a death rate among the American white employees, due to disease, of 5.36 per thousand.

The families of white American employees on the Isthmus averaged in numbers 2,005; among these we had 18 deaths, giving us an annual

death rate of 8.97 per thousand. This I consider a very low rate for this class of population.

The number of our deaths from violence continues large. Of the 789 deaths among employees, we had 157 due to violence, or about one-fifth.

While we had some 50 deaths from beriberi in the total population, only one of these deaths occurred in the person of an employee.

The improvement with regard to dysentery has been steady. During the fiscal year under consideration, we had 35 deaths among employees from dysentery; during the preceding year we had 56 deaths among employees from this disease, though during the fiscal year under consideration we had 10,000 more employees than we averaged during the preceding fiscal year.

During the last fiscal year we had among employees 111 deaths from malarial fever; during the fiscal year preceding we had 211 deaths from malarial fever; that is, with an average force of 10,000 more men than the preceding fiscal year we had only about half the number of deaths from malaria. I consider this the most satisfactory showing in the whole report, as malaria is now the disease against which our sanitary efforts are principally directed.

The decrease in pneumonia has been very steady. During the past fiscal year, among employees, we had 175 deaths from this disease; during the preceding fiscal year we had 479 deaths from this disease. Taking into consideration the increase in the number of employees, this would show that the pneumonia death rate was only about one-fourth of what it was during the preceding fiscal year.

From typhoid fever we had 43 deaths this fiscal year, as compared with 93 deaths from this disease during the preceding fiscal year—less than one-half as many.

It is interesting to note that in the diseases above discussed, the deaths from pneumonia and typhoid fever occurred almost entirely among the blacks.

It is rather remarkable that in our force of 43,000 men we should have admitted to the hospitals only 130 cases of alcoholism, 233 cases of syphilis, and 131 cases of gonorrhea.

Out of every thousand men during the past fiscal year we had 23.85 sick daily; during the preceding fiscal year we had 29.31 constantly sick per thousand. This means a saving of 88,000 sick days for the whole force; that is, if the sick rate had been the same in the two fiscal years we would have had 88,000 more sick days in the last fiscal year.

The cost of subsistence, per day, per patient, averaged during the year $0.297, and the total cost of the care of patients, $1.63 per day, a very economical showing as compared with similar institutions in the States.

During the year we have had no cases of yellow fever or plague originating on the Isthmus.

The figures above given show a very good condition of health, either as compared with any urban population in the United States, or any similar working force in the United States, or with our army and navy.

Very respectfully, yours,

W. C. Gorgas,
Chief Sanitary Officer.

The Chairman Isthmian Canal Commission,
Culebra, Canal Zone.

GENERAL STATISTICS.

Tables showing average number for the year of white and black employees, separately and consolidated, total deaths, average population, total deaths among population, and annual death rates per 1,000 among employees and population, fiscal year, 1907-1908.

	Average population.	Average number of employees.	Total deaths.	Annual average per 1,000.
White employees of the Canal Commission and Panama Railroad Company		12,058	185	15.34
Black employees of the Canal Commission and Panama Railroad Company		30,999	604	19.48
Total employees of the Canal Commission and Panama Railroad Company		[a] 43,057	789	18.32
Panama	35,664		1,242	34.82
Colon	15,271		494	32.34
Canal Zone	61,067		1,364	22.33
Total population	112,002		3,100	27.67

[a] Figures relating to number of employees are compiled from the payrolls of the different months.

NOTE.—The population and deaths as given for the cities of Panama and Colon, and for the Canal Zone, in the tables above, include employees and civil population.

Deaths by color.

White:	
Male	479
Female	194
Black:	
Male	1,625
Female	745
Chinese:	
Male	47
Female	3
Not stated: Male	1
Sex unknown	6
Total	3,100

Deaths by nationality.

Africa	1
Antigua	27
Austria	6
Barbados	247
Bahama Islands	2
Belgium	1
Bohemia	1
Bolivia	1
Canada	1
China	50
Chile	3
Colombia	196
Costa Rica	13
Cuba	8
Curaçao	3
Demerara	4
Dominica	6
Denmark	1
Egypt	1
Ecuador	3
England	15
France	23
Fortune Islands	12
Fiji Islands	1
Greece	10
Germany	6
Grenada	12
Guadaloupe	61
Guiana	1
Haiti	11
Hindustan	1
India	1
Ireland	2
Italy	28
Iceland	1
Jamaica	597
Martinique	139
Mexico	11
Montserrat	13
Norway	1
Nicaragua	5
Nassau	3
Panama	1,122
Peru	7
Porto Rico	4
Portugal	1
Philippines	1
Russia	1
Syria	3
San Salvador	3
Scotland	4
Santo Domingo	2
Spain	157
Sweden	1
Switzerland	1
St. Kitts	3
St. Lucia	66
St. Thomas	10
St. Vincent	9
St. Michaels	1
St. Martin	1
Trinidad	18
Turkey	3
United States	61
Venezuela	7
West Indies	31
Unknown	24
Total	3,100

Deaths by ages.

Under 1 year	600
From 1 to 4 years	142
From 4 to 10 years	73
From 10 to 20 years	197
From 20 to 30 years	686
From 30 to 40 years	472
From 40 to 50 years	397
From 50 to 60 years	220
From 60 to 70 years	81
From 70 to 80 years	40
From 80 to 90 years	11
From 90 to 100 years	1
Not stated	200
Total	3,120

Deaths of Isthmian Canal Commission and Panama Railroad employees by nationality.

Antigua	20
Austria	1
Bohemia	1
Bahama Islands	2
Barbados	192
Belgium	1
Canada	1
Colombia	22
Costa Rica	2
Curaçao	1
Demerara	3
Dominica	4
England	6
France	6
Fortune Islands	12
Fiji Islands	1
Germany	1
Greece	9
Grenada	3
Guadaloupe	49
Haiti	4
Hindustan	1
Ireland	1
Italy	12
Jamaica	131
Mexico	1
Martinique	73
Montserrat	8
Nassau	2
Panama	32
Russia	1
Syria	1
Scotland	1
Spain	90
St. Kitts	1
St. Lucia	18
St. Thomas	1
St. Vincent	8
Switzerland	1
St. Martin	1
Trinidad	10
Turkey	3
United States	42
West Indies	3
Not stated	6
Total	789

Causes of death of Isthmian Canal Commission and Panama Railroad employees.

	White.	Black.	Total.
Alcoholism	3	1	4
Anæmia:			
Pernicious	1	0	1
Simple	1	1	2
Aneurism of abdominal aorta	1	0	1
Aneurism of arch of aorta	0	2	2
Arthritis	0	2	2
Apoplexy	1	1	2
Arterial sclerosis	0	1	1
Aortic insufficiency	1	0	1
Aortitis, vegetative	0	1	1
Appendicitis	1	1	2
Abscess:			
Splenic	0	1	1
Throat	0	1	1
Perirectal	0	1	1
Periurethral	0	1	1
Beriberi	1	0	1
Bronchitis	0	1	1
Bright's disease	0	1	1
Brain, softening of	1	0	1
Colitis, acute	1	2	3
Cancer, abdominal glands	1	0	1
Cardiac dilatation, acute	1	0	1
Dysentery	10	25	35
Diarrhea	0	1	1
Duodenal ulcer	0	1	1
Empyema	0	2	2
Endocarditis	1	2	3
Enteritis	0	1	1
Embolism of cerebral and renal vessels	0	1	1
Entero-colitis	0	1	1
Fever:			
Malarial	35	63	98
Hæmoglobinuric	7	5	12
Blackwater	1	0	1
Typhoid	4	38	42
Typhoid (relapse)	0	1	1
General paresis	1	0	1
Gastric ulcer with perforation	0	1	1
Heart, organic disease of	5	4	9
Hemorrhage, cerebral	1	1	2
Hemorrhage and exhaustion, gastric ulcers	1	0	1
Infection, origin undetermined	1	1	2
Ileo-colitis	1	4	5

	White.	Black.	Total.
Intestinal obstructions	1	2	3
Indigestion, acute	0	1	1
Insanity, alcoholic	0	1	1
Liver:			
Abscess of	6	5	11
Cirrhosis of	3	3	6
Sarcoma of	0	1	1
Ecchinococcus cysts of	1	0	1
Lymphangitis, abdominal	0	1	1
Lungs:			
Abscess of	1	0	1
Gangrene of	0	4	4
Pulmonary tuberculosis of	4	50	54
Tuberculosis miliary	0	6	6
Congestion of	0	1	1
Myelitis	0	1	1
Meningitis	1	16	17
Mitral insufficiency	0	1	1
Mesenteric glands, tuberculosis of	0	1	1
Myocarditis	1	2	3
Nephritis	2	43	45
Osteomyelitis, tuberculous	0	1	1
Pericarditis	0	2	2
Peritonitis	0	3	3
Pleurisy	0	1	1
Pneumonia	7	154	161
Pneumonia, broncho	2	12	14
Pyemia	1	4	5
Pneumothorax, pleura	0	1	1
Pott's disease	0	1	1
Shock from operation, amputation of thigh	0	1	1
Septicæmia	6	9	15
Stomach:			
Cancer of	0	1	1
Ulcer of	1	0	1
Sarcoma of jaw	0	1	1
Syphilis	1	1	2
Stricture of urethra	0	1	1
Tetanus	2	3	5
Tumor of pancreas, malignant	0	1	1
Uncinariasis	0	1	1
Uremia	0	1	1
Violence	63	94	157
Total	185	604	789

List of deaths of white employees from the United States, by months, with totals and death averages per thousand.

JULY, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
			Yrs.	
Harrington, Jas. W	Panama R. R.	9 months	.	Typhoid fever.
Karling, Jas.	Excavating department.	14 months	65	Amebic dysentery and abscess of liver.
Wallion, Michael	Engineering	....	24	Accidental drowning.

AUGUST, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Bragg, Sherman D	Pattern maker	18 months	30	Organic disease of heart.
Pettit, Geo. L	Boiler maker	10 weeks	29	Abscess of liver.
Thornburgh, Eleanore M	Panama R. R.	10 months	35	Septicaemia.

SEPTEMBER, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Sherman, Jos. L	Crane man		36	Broncho-pneumonia.
Twist, E. M	Panama R. R.	10½ years	41	Typhoid fever.

OCTOBER, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Farrell, Patrick	Engineering and construction.	3 months	44	Ulcer of stomach.
Savage, John	do.	21 months	27	Abscess of liver.
Shean, David	Coppersmith	2½ years	36	Accidental traumatism.
Snell, Frank	Train man	14 months	29	Suppurative appendicitis.
Wagner, Adam	Blacksmith	9 months	42	Abscess of liver.

NOVEMBER, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Powers, Edward	Mechanic	16 months	33	Malarial fever, pernicious.
Vande Pool, A. G	do.	5 months	38	Malaria, æstivo-autumnal.

DECEMBER, 1907.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Conant, Frank W.	Foreman		34	Apoplexy.
Cassidy, Frank	Machinist		40	Fracture of skull.
Kramer, Philip F.	Engineer	2½ years		External violence.
Rogers, James S.	Powder man		33	General paresis.
Sturdevant, B. S.	Municipal engineering department.	33 months	30	Accidental drowning.

JANUARY, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Hoard, Samuel R.	Panama R. R.	13 months	.....	Hæmoglobinuric fever.

FEBRUARY, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Davis, Cleon Leslie.	Engineering and construction department.	45 months	.....	Gunshot wound, accidental.

List of deaths of white employees from the United States, by months, with totals and death averages per thousand—Continued.

MARCH, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
			Yrs.	
Cooper, David	Locomotive engineer	2 years	49	Intestinal obstruction.
Forbes, H. D	Mechanical department.	4 months	33	Malaria complicated with nephritis.
Perkins, Mrs. P. I	Teacher	do	27	Amœbic dysentery.
Rich, M. P	Foreman	3 years	33	Abscess of liver.
Sykes, Henry W	Machinist		48	Hemorrhage and exhaustion, gastric ulcers.
Stone, Jean B	Engineer	22 months	42	Malarial fever.

APRIL, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Bath, Geo. K	Engineering and construction department.	4 months	21	Accidental drowning.
Gerdes, Max J	Physician	10 months	39	Organic heart disease.
Loy, Robert Faxon	Conductor	1 year	35	External violence.
Riddle, Paul L	Clerk	2½ years	30	Pulmonary tuberculosis.

MAY, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Brown, John A	Engineering and construction department.	10 months	60	Accidental traumatism.
Coggan, Clifford	Excavation and dredging department.	do	24	Dynamite explosion.
Nice, Ada J	Nurse	13 months	34	Cancer (abdominal).
Roche, Joseph P	Excavation and dredging department.	10 months	34	Dynamite explosion.
Roch, Frank	Foreman	43 months	56	Myocarditis, chronic.

JUNE, 1908.

Name.	Occupation.	Time on Isthmus.	Age.	Cause of death.
Alexandre, John J	Engineering department.	11 months	40	Acute dilatation of heart.
Caswell, Arthur O	Engineering and construction department.	9 months	19	Accidental traumatism (on the Panama R. R.).
O'Shea, Dennis	Excavation and dredging department.		48	Fracture of skull.
O'Brien, Michael J	Panama R. R.	8 months		Cerebral hemorrhage (probably murdered).

Average number of white employees from the United States, on the Isthmus, for the year	5,0[illegible]
Total number of deaths among white employees from the United States for the year	41
Annual average, per 1,000, of deaths among white employees from the United States	[illegible]
Total number of deaths from disease, among white employees from the United States, for the year	27
Annual average, per 1,000, of deaths from disease among white employees from the United States	[illegible]
Total number of deaths from violence, poisoning, etc., among white employees from the United States, for the year	14
Annual average, per 1,000, of deaths from violence, poisoning, etc., among white employees from the United States	2.75

Deaths of white American women and children.

Name.	Time on Isthmus.	Age.	Cause of death.
AUGUST, 1907.			
Thornburgh, Eleanore M.	10 months	33 years	Septicæmia.
OCTOBER, 1907.			
MacIntyre (baby)	1 day	1 day	Cerebral paralysis.
Ortega, Mary		57 years	Nephritis, chronic.
Scherburgh, Albert	9 months	9 months	Malarial fever.
NOVEMBER, 1907.			
Hern, Mrs. John P.		28 years	Hæmoglobinuric fever.
DECEMBER, 1907.			
Atterbury, Mrs. C. L.	6 months		Hyperemesis gravidaum.
Evans, Edith Emma	3 months		Capillary bronchitis.
MARCH, 1908.			
Cate, Charles I.	3 days	5 months	Capillary bronchitis.
Colegrove, Sybil	4 months	3 years	Fracture at base of skull; accident.
Daken (baby)	3 days	3 days	Congenital heart disease.
Perkins, Mrs. P. I.	4 months	27 years	Amœbic dysentery.
APRIL, 1908.			
Boyd (baby)	1 hour	1 hour	Premature birth.
Costley, Percival F.	4 months	8 years	Accidental drowning.
MAY, 1908.			
Beattie (baby)	3 days	3 days	Meningitis.
Nice, Ada J.	13 months	34 years	Cancer (abdominal).
O'Day, Mrs. William	6 months	22 years	Malnutrition, with vomiting of pregnancy.
JUNE, 1908.			
Smith, Charles Le Roy	8 months	11 months	Convulsions.
Dennis, Wilhelmina Goethals.	3 months	3 months	Cholera infantum.

Average number of white American women and children on the Isthmus for the year	2,005
Total number of deaths among white American women and children for the year	18
Annual average, per 1,000, of deaths among white American women and children	8.97
Total number of deaths from disease among white American women and children for the year	15
Annual average, per 1,000, of deaths from disease among white American women and children	7.48
Total number of deaths from violence, premature birth, etc., among white American women and children	3
Annual average, per 1,000, of deaths from violence, premature birth, etc., among white American women and children	1.49
Average number of white Americans connected with the Isthmian Canal Commission and Panama Railroad for the year (Americans and their families)	7,040
Total number of deaths from all causes among white Americans connected with the Isthmian Canal Commission and Panama Railroad	59
Annual average, per 1,000, of deaths from all causes among white Americans connected with the Isthmian Canal Commission and Panama Railroad	8.38
Total number of deaths from disease among white Americans connected with the Isthmian Canal Commission and Panama Railroad	42
Annual average, per 1,000, of deaths from disease among white Americans connected with the Isthmian Canal Commission and Panama Railroad	5.96
Total number of deaths from violence, premature birth, poisoning, etc. among white Americans connected with the Isthmian Canal Commission and Panama Railroad	17
Annual average, per 1,000, of deaths from violence, poisoning, premature birth, etc., among white Americans connected with the Isthmian Canal Commission and Panama Railroad	2.41

Causes of death.

[Embracing employees of the Canal Commission and Panama Railroad Company, and also the deaths among the civil population.]

Diseases.	Ancon Hospital.	Colon Hospital.	Line Hospital.	Panama.	Colon.	Zone.	Total.
I.—General diseases.							
Typhoid fever (abdominal typhus)	25	21	1	4		5	[illegible]
Relapsing fever				1			[illegible]
Malarial fever	2	53	7	48	32	55	[illegible]
Aestivo-autumnal-malaria	24	7	4	34	3	14	[illegible]
Clinical malaria	4	15		86	29	61	[illegible]
Malarial cachexia		1	2	4		5	[illegible]
Hæmoglobinuric fever	6	8	1	4		2	[illegible]
Measles					1		[illegible]
Dysentery	6		2	13	1	8	[illegible]
Amœbic	25	14	2				[illegible]
Clinical	4		1	20	3	6	[illegible]
Leprosy						[a] 1	[illegible]
Beriberi	1			45		4	[illegible]
Purulent infection and septicæmia	10	16	1	3	3	2	[illegible]
Rabies	1			1			[illegible]
Tuberculosis of the lungs	40	30	11	153	20	50	[illegible]
Tuberculosis of the meninges		3		3			[illegible]
Abdominal tuberculosis	2			1			[illegible]
Pott's disease		1					[illegible]
Tuberculosis of other organs	3	1					[illegible]
General tuberculosis	17	14	1	10		1	[illegible]
Scrofula				1			[illegible]
Syphilis	1	2	1	6	1		[illegible]
Cancer and other malignant tumors of the buccal cavity		1		2			[illegible]
Cancer and other malignant tumors of stomach and liver	2	1		8		1	[illegible]
Cancer and other malignant tumors of peritoneum, intestines, and rectum	1	1	1				[illegible]
Cancer and other malignant tumors of the female genital organs		1		6			[illegible]
Cancer and other malignant tumors of the breast					1		[illegible]
Cancer and other malignant tumors of other organs or of organs not specified	2	1		3			[illegible]
Other tumors (tumors of the female genital organs excepted)				1			[illegible]
Acute articular rheumatism				3		4	[illegible]
Chronic rheumatism and gout				1			[illegible]
Diabetes		1					[illegible]
Leukæmia				2			[illegible]
Anæmia, chlorosis	2	1		4	1	4	[illegible]
Other general diseases	1					1	[illegible]
Acute and chronic rheumatism				4			[illegible]
Other chronic poisoning				7	1	2	[illegible]
II.—Diseases of the nervous system and the organs of special sense.							
Simple meningitis	4	2	1	8	10	3	[illegible]
Epidemic cerebro-spinal meningitis	4					1	[illegible]
Pneumococcus meningitis	2	6		3		1	[illegible]
Other diseases of the spinal cord	1					1	[illegible]
Congestion and hemorrhage of the brain	2	3		15	8	7	[illegible]
Softening of the brain	1			2			[illegible]
Paralysis without specified cause				7	1		[illegible]
General paralysis	3		1				[illegible]
Other forms of mental alienation	3		2	1			[illegible]
Epilepsy				1	1	1	[illegible]
Convulsions (nonpuerperal, 5 years and over)					2		[illegible]
Convulsions (under 5 years)				5	9	12	[illegible]
Tetanus	3	3		28	2	2	[illegible]
Other diseases of the nervous system	1			1			[illegible]
Diseases of the eye and its adnexa				1			[illegible]
Diseases of the ear				1			[illegible]
III.—Diseases of the circulatory system.							
Pericarditis	1						[illegible]
Acute endocarditis	2			21			[illegible]
Septic endocarditis		2		1		1	[illegible]
Organic diseases of the heart	10	5	2	23	18	17	[illegible]
Angina pectoris				4			[illegible]
Diseases of the arteries (atheroma, aneurism, etc.)	5	5	1	5		2	[illegible]
Embolism and thrombosis		1					[illegible]
Hemorrhages		1		5	2	2	[illegible]
Other diseases of the circulatory system				2	2		[illegible]

[a] Death of leper occurred at Palo Seco Leper Asylum.

Causes of death—Continued.

Diseases.	Ancon Hospital.	Colon Hospital.	Line Hospital.	Panama.	Colon.	Zone.	Total.
IV.—*Diseases of the respiratory system.*							
Diseases of the larynx				1	1		2
Acute bronchitis	1			18	3	3	25
Chronic bronchitis				1	2	1	4
Broncho-pneumonia	18	6		20	4	7	55
Pneumonia	80	88	10	86	20	44	328
Pleurisy	1	1		1	2	1	6
Congestion and apoplexy of the lungs			1	8			9
Gangrene of the lungs	8					1	9
Asthma				2	1		3
Other diseases of the respiratory system (phthisis excepted)				2	1	1	4
V. *Diseases of the digestive system.*							
Diseases of the mouth and its adnexa						2	2
Diseases of the pharynx						1	1
Diseases of the esophagus				2			2
Ulcer of the stomach	1	1			1	1	4
Other diseases of the stomach (cancer excepted)		1		6	2		9
Diarrhea and enteritis (under 2 years)				147	16	26	189
Chronic diarrhea and enteritis (under 2 years)				12	1		13
Diarrhea and enteritis (2 years and over)	12	1		31	7	6	57
Intestinal parasites				3		9	12
Uncinariasis	2	2				1	5
Hernia and intestinal obstructions	1	1	2	6		3	13
Other diseases of the intestines	2			5	1		8
Hydatid tumors of the liver	1						1
Cirrhosis of the liver	4	3		17	1	2	27
Biliary calculi				3			3
Other diseases of the liver	8	7		8			23
Diseases of the spleen	1	1					2
Simple peritonitis	2	3		2	3	3	13
Other diseases of the digestive system (cancer and tuberculosis excepted)				3	1	2	6
Appendicitis and abscess of the iliac fossa	1	1		1			3
VI. *Diseases of the genito-urinary system and its adnexa.*							
Acute nephritis	13	9		28	5	6	61
Bright's disease	18	44		39	4	9	114
Other diseases of the kidneys and their adnexa		3			1		4
Calculi of the urinary tract				1			1
Diseases of the bladder	1						1
Diseases of the urethra, urinary abscess, etc	2	1					3
Uterine tumors (noncancerous)				1			1
Other diseases of the uterus				2			2
Cysts and other tumors of the ovary				1			1
VII. *The puerperal state.*							
Accidents of pregnancy	2	1		1	2	1	7
Puerperal hemorrhage						2	2
Other accidents of labor					1	3	4
Puerperal septicæmia		2		4	1	3	10
Puerperal albuminuria and convulsions	1			1			2
VIII. *Diseases of the skin and cellular tissue.*							
Gangrene	4			1			5
Acute abscess, phlegmon				1	1	1	3
Other diseases of the skin and its adnexa				1			1
IX. *Diseases of the organs of locomotion.*							
Nontuberculous diseases of the bones				2			2
Arthritis and other diseases of the joints (tuberculosis and rheumatism excepted)	2			1			3
X. *Malformations.*							
Congenital malformations (stillbirths excepted)				1	1		2
XI. *Early infancy.*							
Congenital debility, icterus and sclerema	2	3	1	17	23	59	105
Other diseases peculiar to early infancy		1		13	15	9	38
Lack of care				3			3

Causes of death—Continued.

Diseases.	Ancon Hospital.	Colon Hospital.	Line Hospital.	Panama.	Colon.	Zone.
XII. *Old age.*						
Senile debility				5	5	8
XIII. *External causes.*						
Suicide by poisoning				1		
Suicide by drowning		1				
Suicide by firearms				3		1
Suicide by cutting instruments					2	
Other suicides				1		2
Fractures	5	5		5		[a] 12
Other accidental traumatisms	18	19	8	4	3	91
Burns and scalds	1			1		1
Sunstroke					1	
Electric shock						3
Accidental drowning				3	3	48
Absorption of deleterious gases (nonsuicidal)					1	
Other acute poisoning	1			1		1
Other external violence	1	1				3
XIV. *Ill-defined diseases.*						
Dropsy				2	1	6
Sudden death				2		1
Causes of death unspecified or ill-defined	1		2	43	5	32
Total	436	427	66	1,186	293	692
Stillbirths				93	45	42

[a] One death from fracture occurred at Taboga Sanitarium.

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission for the fiscal year 1907–8 from all causes.

Diseases.	Discharged.
I. *General diseases.*	
Typhoid fever	368
Relapsing fever	11
Malarial fever	816
Æstivo-autumnal malaria	3,837
Tertian malaria	2,200
Mixed malaria	185
Clinical malaria	4,849
Malarial cachexia	200
Hæmoglobinuric fever	29
Measles	38
Influenza	98
Dysentery	163
Bacillary	2
Amœbic	96
Clinical	66
Leprosy	2
Beriberi	4
Erysipelas	7
Other epidemic diseases	10
Purulent infection and septicæmia	9
Tuberculosis of the lungs	111
Tuberculosis of the meninges	
Pott's disease	2
Cold abscess and abscess by congestion	123
Tuberculosis of other organs	12
General tuberculosis	13
Syphilis	233
Gonorrhea	131
Cancer and other malignant tumors of stomach and liver	1
Cancer and other malignant tumors of peritoneum, intestines, and rectum	2
Cancer and other malignant tumors of the skin	11
Cancer and other malignant tumors of other organs or of organs not specified	4
Other tumors (tumors of the female genital organs excepted)	3
Acute articular rheumatism	57
Chronic rheumatism and gout	30

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission for the fiscal year 1907-8 from all causes—Continued.

Diseases.	Discharged.	Died.
I. *General diseases*—Continued.		
Exophthalmic goiter	1	......
Leukæmia	2	......
Anæmia, chlorosis	87	2
Other general diseases	550	1
Acute and chronic rheumatism	92	......
Chronic lead poisoning	6	......
Other chronic poisoning (occupational)	3	......
Other chronic poisoning	74	1
II. *Diseases of the nervous system and the organs of special sense.*		
Simple meningitis	5	7
Epidemic cerebro-spinal meningitis	....	4
Pneumococcus meningitis	1	4
Progressive locomotor ataxia	4	......
Congestion and hemorrhage of the brain	1	2
Softening of the brain	....	1
Paralysis without specified cause	5	......
General paralysis	1	......
Other forms of mental alienation	17	2
Epilepsy	10	......
Convulsions (nonpuerperal)	1	......
Tetanus	....	4
Other diseases of the nervous system	150	......
Diseases of the eye and its adnexa	426	......
Diseases of the ear	200	......
III. *Diseases of the circulatory system.*		
Pericarditis	1	1
Pneumococcus pericarditis	....	1
Acute endocarditis	4	2
Septic endocarditis	....	2
Organic diseases of the heart	25	11
Diseases of the arteries (atheroma, aneurism, etc.)	9	3
Embolism and thrombosis	....	1
Diseases of the veins (varices, hemorrhoids, phlebitis, etc.)	106	2
Diseases of the lymphatic system (lymphangitis, etc.)	112	1
Hemorrhages	8	2
Other diseases of the circulatory system	26	1
IV. *Diseases of the respiratory system.*		
Diseases of the nasal fossæ	37	......
Diseases of the larynx	43	......
Diseases of the thyroid body	2	......
Acute bronchitis	196	......
Chronic bronchitis	37	......
Broncho-pneumonia	9	15
Pneumonia	428	142
Pleurisy	62	1
Congestion and apoplexy of the lungs	2	......
Gangrene of the lungs	....	4
Asthma	19	......
Pulmonary emphysema	21	1
Other diseases of the respiratory system (phthisis excepted)	103	3
V. *Diseases of the digestive system.*		
Diseases of the mouth and its adnexa	33	......
Diseases of the pharynx	36	......
Ulcer of the stomach	2	2
Other diseases of the stomach (cancer excepted)	83	1
Chronic diarrhea and enteritis	11	......
Diarrhea and enteritis	335	1
Intestinal parasites	9	......
Uncinariasis	112	2
Hernia and intestinal obstructions	210	1
Other diseases of the intestines	88	10
Cirrhosis of the liver	16	4
Biliary calculi	6	......
Other diseases of the liver	48	12
Diseases of the spleen	7	2
Simple peritonitis	7	6
Other diseases of the digestive system (cancer and tuberculosis excepted)	68	......
Appendicitis and abscess of the iliac fossa	41	2

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission for the fiscal year 1907–8 from all causes—Continued.

Diseases.	Discharged.
VI. *Diseases of the genito-urinary system and its annexa.*	
Acute nephritis	62
Bright's disease	32
Other diseases of the kidneys and their adnexa	47
Calculi of the urinary tract	1
Diseases of the bladder	43
Diseases of the urethra, urinary abscess, etc	146
Diseases of the prostate	4
Nonvenereal diseases of the male genital organs	327
Uterine tumors (noncancerous)	2
Other diseases of the uterus	3
Other diseases of the female genital organs	3
Nonpuerperal diseases of the breast (cancer excepted)	1
Chancroids	58
VII. *The puerperal state.*	
Accidents of pregnancy	3
VIII. *Diseases of the skin and cellular tissue.*	
Gangrene	....
Furuncle	104
Acute abscess, phlegmon	152
Other diseases of the skin and its adnexa	313
IX. *Diseases of the organs of locomotion.*	
Nontuberculous diseases of the bones	26
Arthritis and other diseases of the joints (tuberculosis and rheumatism excepted)	72
Amputation	29
Other diseases of the organs of locomotion	67
X. *Malformations.*	
Congenital malformations (stillbirths excepted)	16
XII. *Debility.*	
Debility	60
XIII. *External causes.*	
Suicide by drowning	....
Fractures	212
Dislocation	21
Other accidental traumatisms	888
Burns and scalds	42
Sunstroke	1
Other acute poisoning	56
Other external violence	141
Not sick	22
X-ray examination	1
XIV. *Ill-defined diseases.*	
Causes unspecified or ill defined	12
Total	20,748

Consolidated hospital report, fiscal year 1907–8.

Hospitals.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Ancon Hospital:						
Employees	423	11,987	321	10,360	1,230	499
Nonemployees	82	1,118	95	980	32	93
Insane	0	259	20	60	0	179
Total	505	13,364	436	11,400	1,262	771
Colon Hospital:						
Employees	285	7,049	250	6,649	188	247
Nonemployees	78	1,333	177	1,155	13	66
Total	363	8,382	427	7,804	201	313
Palo Seco Leper Asylum:						
Employees	0	2	0	1	0	1
Nonemployees	11	8	0	0	0	19
Total	11	10	0	1	0	20
Taboga Sanitarium:						
Employees	33	2,400	0	2,399	0	34
Nonemployees	7	633	1	639	0	0
Total	40	3,033	1	3,038	0	34
Miraflores Hospital:						
Employees	5	41	6	12	28	0
Nonemployees	114	93	16	31	160	0
Total	119	134	22	43	188	0
Paraiso Hospital:						
Employees	7	352	6	306	47	0
Nonemployees	0	1	0	1	0	0
Total	7	353	6	307	47	0
Culebra Hospital:						
Employees	36	419	12	405	38	0
Nonemployees	1	10	4	7	0	0
Total	37	429	16	412	38	0
Empire Hospital:						
Employees	12	322	1	265	68	0
Las Cascadas Hospital:						
Employees	13	205	2	195	21	0
Nonemployees	0	5	1	3	1	0
Total	13	210	3	198	22	0
Bas Obispo Hospital:						
Employees	9	277	3	246	37	0
Gorgona Hospital:						
Employees	8	184	3	150	39	0
Nonemployees	0	7	3	4	0	0
Total	8	191	6	154	39	0
Gatun Hospital:						
Employees	15	816	7	730	94	0
Nonemployees	0	2	1	0	1	0
Total	15	818	8	730	95	0
Total number of employees remaining in hospitals						781
Grand total	1,139	27,523	929	24,598	1,997	1,138

Cost of subsistence:	
Number of days' rations issued to patients	399,880
Total cost of rations issued to patients	$122,116.86
Cost of subsistence per patient per day	$0.3053+
Operating expenses:	
Number of days' relief furnished	399,880
Total cost of hospitals	$687,922.269
Cost per patient per day	$1.72

Consolidated sick camp report, fiscal year 1907–8.

Sick camps.	Remaining June 30, 1907.	Admitted and excused for quarters.	Died.	Discharged.	Transferred.	Rem[illegible]
Porto Bello	6	1,386	0	986	397	[illegible]
San Pablo		506	1	434	67	[illegible]
Pedro Miguel	4	933	0	772	145	[illegible]
La Boca	11	3,292	0	3,109	187	[illegible]
Tivoli		2,621	0	2,576	40	[illegible]
Cristobal	5	907	0	761	140	[illegible]
Corozal	2	1,354	0	1,026	330	
Tabernilla	7	2,726	1	1,972	751	[illegible]
Gatun	5	3,130	1	2,732	380	[illegible]
Gorgona	9	3,080	0	2,667	415	[illegible]
Bas Obispo	20	2,179	0	1,873	315	[illegible]
Miraflores		461	0	361	100	
Las Cascadas	1	1,548	7	1,380	151	[illegible]
Paraiso	12	2,991	2	2,822	170	[illegible]
Culebra	3	2,577	4	2,246	302	[illegible]
Empire	8	4,161	1	4,064	67	[illegible]
Total	93	33,842	17	29,801	3,957	[illegible]

Cost of subsistence:
- Number of days' rations issued to patients .... [illegible]
- Total cost of rations issued to patients .... $12[illegible]
- Cost of subsistence, per patient, per day .... $[illegible]

Operating expenses:
- Number of days' relief furnished .... [illegible]
- Total cost of sick camps .... $53,[illegible]
- Cost, per patient, per day .... $[illegible]

Consolidated hospital and sick camp report.

	Remaining June 30, 1907.	Admitted and excused for quarters.	Died.	Discharged.	Transferred.	Rem[illegible]
Hospitals	1,139	27,523	929	24,598	1,997	[illegible]
Sick camps	93	33,842	17	29,801	3,957	[illegible]
Total	1,232	61,365	946	54,399	5,954	[illegible]

Total admissions to hospitals and sick camps (including employees excused from work for quarters) during year .... [illegible]

Less patients transferred from one hospital to another, from sick camps to hospitals, and from hospitals to Taboga Sanitarium, whose admissions are duplicated .... [illegible]

Net admissions to hospitals, sick camps, and employees excused from work for quarters. [illegible]

Cost of subsistence:
- Number of days' rations issued to patients .... [illegible]
- Total cost of rations issued to patients .... $134.[illegible]
- Cost of subsistence, per patient, per day .... $[illegible]

Operating expenses:
- Number of days' relief furnished patients .... [illegible]
- Total cost of hospitals and sick camps .... $741,[illegible]
- Cost per patient, per day .... $[illegible]

Consolidated dispensary report, fiscal year 1907–8.

Class.	White.	Black.	To[illegible]
Employees	212,347	135,077	[illegible]
Nonemployees	19,338	10,027	[illegible]
Total	231,685	145,104	[illegible]

Operating expenses, dispensaries: Total cost of dispensaries, $188,736.443.

Average number of employees constantly sick during year in hospitals, sick camps, and quarters.

	White.	Black.	Total.
Ancon Hospital	223.38	218.19	441.57
Colon Hospital	101.33	139.58	240.91
Palo Seco Leper Asylum		.43	.43
Taboga Sanitarium	45.97		45.97
Miraflores Hospital	1.16	10.77	11.93
Paraiso Hospital	3.61	5.51	9.12
Culebra Hospital	9.64	7.66	17.30
Empire Hospital	9.12	5.37	14.49
Las Cascadas Hospital	1.58	.78	2.36
Bas Obispo Hospital	8.84	5.05	13.89
Gorgona Hospital	2.33	5.47	7.80
Gatun Hospital	20.60	12.33	32.93
Total	427.56	411.14	838.70

Average number of white employees sick daily in hospitals, per thousand 35.45
Average number of black employees sick daily in hospitals, per thousand 13.26
Average number of white and black employees sick daily in hospitals, per thousand 19.47

Sick camps and quarters.

	White.	Black.	Total.
Tivoli	3.74	3.88	7.62
La Boca	6.54	3.34	9.88
Corozal	3.95	2.23	6.18
Miraflores	3.10	2.97	6.07
Pedro Miguel	8.48	4.06	12.54
Paraiso	8.44	3.64	12.08
Culebra	9.02	4.78	13.80
Empire	11.22	6.22	17.44
Las Cascadas	7.27	2.23	9.50
Bas Obispo	8.50	6.31	14.81
Gorgona	5.62	4.45	10.07
San Pablo	2.68	1.37	4.05
Tabernilla	3.52	9.46	12.98
Gatun	9.12	14.42	23.54
Cristobal	6.14	8.43	14.57
Porto Bello	8.49	4.68	13.17
Total	105.83	82.47	188.30

Average number of white employees sick daily in sick camps, per thousand 8.77
Average number of black employees sick daily in sick camps, per thousand 2.66
Average number of white and black employees sick daily in sick camps, per thousand 4.37
Average number of white employees sick daily in hospitals, sick camps, and quarters 533.39
Average number of white employees sick daily in hospitals, sick camps, and quarters, per thousand. 44.23
Average number of black employees sick daily in hospitals, sick camps, and quarters 493.61
Average number of black employees sick daily in hospitals, sick camps, and quarters, per thousand. 15.92
Average number of white and black employees sick daily in hospitals, sick camps, and quarters.. 1,027.00
Average number of white and black employees sick daily in hospitals, sick camps, and quarters, per thousand 23.85

Report of all surgical operations performed in hospitals of the Isthmian Canal Commission for the fiscal year 1907-8.

Amputations:	
Arm	12
Breast (Halstead's operation)	2
Disarticulation—	
Shoulder	3
At hip (Wyeth's operation)	2
Feet	12
Fingers	4
Hand	3
Hip joint	1
Leg	17
Leg, double (Truma)	1
Shoulder joint	1
Thigh	13
Toe	1
Adenectomy:	
Inguinal	375
Femoral	12
Axillary	1
Cervical	13
Supra-trochlear	1
Abscess:	
Ventral	1
Psoas, lumbar incision	3
Ischio rectal	2
Incised	7
Arthritis of knee, incised and drained, septic	3
Curettage, uterine	20
Cellulitis of thigh and leg	4
Excision of—	
Breast	1
Ankle joint (tubercle)	1
Goitre	1
Fibro lipoma of chest	1
Empyema:	
Resection of ribs	32
Abscess of liver	1
Eye, ear, nose, and throat operations:	
Advancement—	
External rectus	3
Internal rectus	2

Report of all surgical operations performed in hospitals of the Isthmian Canal Commission for the fiscal year 1907–8—Continued.

Eye, ear, nose, and throat operations—Con.	
Abscess, lachrymal sac	1
Adenoids	1
Aural polypi removed	2
Pterygium	19
Double	3
Septal resections	30
Drainage of highmore	1
Tonsillotomy with nasal adenectomy	15
Tonsillotomy	15
Tracheotomy	5
Cataract extraction	14
Cataract, needled	16
After cataract discission	4
Ligation vessels, interstitial keratitis	1
Mastoid	8
Frontal sinus	6
Hæmatoma, auricle	1
Myxomatous polypi removed	4
Nasal polypi	14
Trachoma—	
Rolled	12
Expressions	22
Torsal tumors, incised and curetted	5
Plastic on face and nose	1
Plastic for ectropion	1
Plastic on nose	4
Plastic on eye	1
Plastic on ear	1
Plastic on lid	1
Tenotomy	4
Iridectomy	7
Ossiculectomy	1
Stricture lachrymal duct	3
Paracentesis	51
Furuncle	12
Enucleation of eye	10
Papilloma in nose removed	1
Uvulotomy	1
Evisceration of eye	7
Cauterization of turbinate bones	4
Kiliani	1
Minor eye, ear, nose, and throat operations	631
Fractures—	
Skull	5
Skull with hemorrhage	1
Skull, compound	6
Spine	1
Femur, wired	3
Compound—	
Wired femur	9
Leg	1
Thigh	2
Inferior maxilla	1
Face bones	1
Wrist	1
Ankle	2
Arm	1
Humerus	1
Tibia and fibula	8
Carpals	1
Wired tibia	2
Small bones	1
Wired—	
Clavicle	1
Ulna	1
Radius and ulna, wired	1
Fistula in ano	3
Fibromyema of breast	1
Hernia:	
Inguinal	196
Double	68
Double with femoral hernia	1
Strangulated	8
Ventral	8
Femoral strangulated	1
Umbilical	4
Femoral	2
Hemorrhoids	41
Clamp and cautery	4
Whitehead's	28
Clamp and ligature	16
Hydrocele	47
Double	6
Radical	34

Kidney, exploratory and decapsulation	
Laparotomies, for—	
Abscess of liver	
Multiple	
Appendectomy	
Appendectomy and salpingectomy	
Appendostomy for dysentery	
Amœbic perforation	
Appendecostomy	
Blood cyst of spleen	
Cholecystostomy	
Cecostomy	
Cecostomy for dysentery	
Colostomy, left inguinal	
Cirrhosis of liver (Schiassi)	
Colostomy, closure	
Closure of fecal fistula	
Dudley's round ligament suspensio uteri	
Round ligament suspensio uteri and appendectomy	
Exploratory (hemorrhage)	
Exploratory	
Exploratory hepatotomy	
Extra uterine pregnancy ruptured	
Ectopic gestation	
Enterorrhaphy for typhoid perforation	
Gestation	
Gunshot wound of intestines and mesentery	
Hysteromyomectomy	
Hysterectomy and appendectomy	
Hysterectomy	
Hemorrhage, traumatic	
Intestinal obstruction	
Lumbar nephrotomy for pyonephrosis	
Multiple gastric ulcers	
Ovarian cystectomy	
Ovariotomy	
Oophorectomy, double	
Pelvic inflammatory disease	
Pelvic adhesions	
Pelvic abscess	
Peritonitis—	
General	
Appendical origin	
Perforation, typhoid ulcer	
Appendix	
Ruptured intestines	
Ecchinococcus	
Tuberculosis	
Traumatic	
Amœbic	
Chronic, with fecal fistula	
Local	
Pelvic	
Local appendix	
Chronic adhesive	
And appendectomy	
Pneumococcic	
Panhysterectomy	
Perityphlitis, chronic	
Prolapse, both ovaries	
Ruptured spleen	
Rupture, gastro-colic omentum	
Stab wound of abdomen	
Salpingo-oophorectomy	
Salpingo-oophorectomy and appendectomy	
Salpingo-myomectomy and appendectomy	
Salpingectomy, double and appendectomy	
Splenectomy	
Subphrenic abscess	
Sigmoidopexy	
Talma	
Ventral hernia	
Ventral suspension of uterus	
Wound of abdomen	
Oophorectomy and appendectomy	
Laminectomy	
Laminectomy for fracture of spine	
Orchidectomy	
Orchidectomy and lymphangitis	
Osteomyelitis	
Perineorrhaphy	
Perineorrhaphy and trachelorrhaphy	
Pneumonotomy	

Report of all surgical operations in hospitals of the Isthmian Canal Commission for the fiscal year 1907–8—Continued.

Pneumonorrhaphy	1
Resection of—	
Knee	1
Rectum	1
Wrist (tuberculosis)	1
Elbow joint	1
Repair of lacerated muscles of thigh	1
Repair of lacerated wounds of trachea and throat	1
Reduction of hip dislocation	1
Suture of lung for traumatic hemorrhage	1
Skin graft	17
Stricture urethra:	
Internal operation	3
Perineal	4
Stricture urethra	10
Stricture of rectum	1
Sequestrotomy for caries of—	
Inferior maxillæ	1
Oscalcis	1
Trachelorrhaphy	9
Trachelorrhaphy and perineorrhaphy	1
Trephine for Jacksonian epilepsy	1
Trephine for gunshot wound of skull	1
Thigh, stab wound into femoral vein	1
Trephine for intercranial hemorrhage	1
Trephine for fractured skull	3
Trephine for caries of calvarium	1
Thoracostomy for pyopneumothorax	1
Thoracostomy for trauma	1
Throplasty, Schede's operation	1
Thyroidectomy	1
Urethrotomy:	
Perineal	22
Internal	29
Varicose veins	2
Varicose veins (Mayo)	4
Varicocele	40
Various major operations	216
Various minor operations	2,755
Total (major operations, 2,105; minor operations, 3,386)	5,491

Consolidated laboratory report of all hospitals.

Blood examinations	18,933
Æstivo-autumnal	4,481
Tertian, single	2,532
Tertian, double	252
Tertian and æstivo-autumnal	153
Spirrillum obermeieri	4
Mixed æstivo-autumnal and crescents	12
Mixed æstivo-autumnal and tertian	1
Widal reactions (positive 86)	577
Æstivo-autumnal and double tertian	5
Triple tertian	2
Spirrillum obermeieri	30
Guiac-turpentine tests for invisible blood	295
Leucocytes	1,422
Differential counts	285
Hæmoglobin estimations	137
Red blood cells	139
White blood cells	60
Erythrocyte counts	1
Filarial infections	98
Negative	5,358
Differential leucocyte counts	173
Hæmoglobin determinations	2,352
Stool examinations	20,566
Ascaris lumbricoides	1,456
Uncinaria ova	2,295
Tricocephalus dispar	3,453
Strongyloides	682
Bilharzia	33
Oxyuris	4
Tænia	25
Amœba coli	758
Amœba dysenteria	54
Stool examinations—Continued.	
Ciliated monads	533
Pus and blood	1,093
Balantidium coli	25
Tubercle bacilli	11
Ova of ankylostomum duodenale	633
Ova of schistosomum hæmotobium	6
Cercomonas intestinalis	321
Negative	4,668
Bacillus tuberculosis (positive 3)	37
Flagellated monads	406
Urine examinations	23,096
Albumen	7,827
Albumen and casts	1,107
Sugar	17
Urethral discharge	1
Gonococci	5
Urinalysis	13
Pus and blood	11
Bacillus tuberculosis (negative)	26
Bile	17
Hæmoglobin	9
Microscopical examinations	682
Indican	2
Bence-Jones's body, positive	1
Diazo reactions (positive 45)	223
Sputum examinations	1,494
Tubercular bacilli	206
Pneumococci	15
Amœba	1
Hydrocele fluid	1
Pleural effusion	1
Negative	900
Examination of pus, blood, and tissues	77

Pathological report.[a]

Post-mortem examinations	424
Embalming	4
Celloidin sections examined	206
Post-mortem	892
Operative	218
Bacteriological examination of catgut (negative)	7
Wright's stain prepared (c. c.)	2,860
Cultures from splenic puncture (negative)	3
Paraffin sections:	
Post-mortem	733
Operative	60
Examination of exudates	33
Examination of fetuses	2
Smears for treponema pallidium (positive 1)	2
Gastric contents	5
Examination of stomach contents	1
Blood cultures	11
Miscellaneous	33
Lumbar punctures	5
Examination of smears for bacillus lepræ (negative)	3
Inoculation of guinea pig	1

[a] Additional work performed of this nature appears under section "Board of health laboratory."

REPORT OF ANCON HOSPITAL.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining [illegible]
Isthmian Canal Commission employees	[illegible]	[illegible]	[illegible]	9,794	[illegible]	[illegible]
Panama Railroad employees	46	384	15	[illegible]	[illegible]	[illegible]
Ex-employees	13	7	0	25	6	
Pay patients	22	[illegible]	25	[illegible]	[illegible]	[illegible]
Charity patients	32	454	[illegible]	[illegible]	[illegible]	
Insane patients	6	250	[illegible]	[illegible]	9	[illegible]
Total	[illegible]	[illegible]	[illegible]	11,400	[illegible]	[illegible]

Average number of days' treatment per patient for the year.................... [illegible]
Average number of white employees constantly sick during year.................... [illegible]
Average number of black employees constantly sick during year.................... [illegible]
Average number of white and black employees constantly sick.................... [illegible]
Cost of subsistence per patient per day.................... $ [illegible]

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	[illegible]	[illegible]	17	[illegible]	[illegible]
Panama Railroad employees	660	44	1	[illegible]	[illegible]
Ex-employees	25	0	0	[illegible]	[illegible]
Pay patients	680	331	0	[illegible]	[illegible]
Charity cases	486	56	0	64	[illegible]
Insane	250	6	0	23	[illegible]
Total	[illegible]	2,713	[illegible]	[illegible]	[illegible]

Laboratory report.

Blood examinations	9,592
Æstivo-autumnal	2,334
Tertian [illegible]	1,348
Tertian, double	107
Tertian and æstivo-autumnal	57
Spirillum obermeieri	4
Mixed æstivo-autumnal and crescents	12
Mixed æstivo-autumnal and tertian	1
Blood count	961
Leucocytes	725
Differential counts	260
Hæmoglobin estimations	115
Red blood cells	8
White blood cells	13
Stool examinations	10,803
Ascaris lumbricoides	667
Uncinaria ova	1,617
Trichocephalus dispar	1,393
Strongyloides	202
Bilharzia	28
Oxyuris	3
Tænia	25

Stool examinations—continued.	
Amœba coli	[illegible]
Amœba dysenteria	[illegible]
Ciliated monads	[illegible]
Pus and blood	[illegible]
Balantidium coli	[illegible]
Tubercle bacilli	[illegible]
Urine examinations	[illegible]
Albumen	[illegible]
Albumen and casts	[illegible]
Sugar	[illegible]
Urethral discharge	[illegible]
Gonococci	[illegible]
Urinalysis	[illegible]
Pus and mucus	[illegible]
Sputum examinations	[illegible]
Tubercular bacilli	[illegible]
Pneumococci	[illegible]
Amœba	[illegible]
Hydrocile fluid	[illegible]
Pleural effusion	[illegible]
Examination of pus, blood, and tissues	[illegible]

Operations.

Amputations:	
Leg	10
Foot	11
Shoulder joint	1
Hand	2
Hip joint	1
Thigh	3
Leg, double (trauma)	1
Forearm	2
Arm	3
Adenectomy:	
Inguinal	220
Inguinal and femoral double, filarial	1
Inguinal, double	19
Femoral	1
Axillary	1
Cervical, tuberculous	6
[illegible]cer of breast (Halstead's operation)	1

Curettage, uteri	[illegible]
Excision of—	
Breast	[illegible]
Ankle joint (tubercle)	[illegible]
Goiter	1
Empyema:	
Resection of ribs	4
Simple resection	[illegible]
Beck's resection	[illegible]
Abscess, liver	1
Eye, ear, nose, and throat operations:	
Advancement—	
External rectus	[illegible]
Internal rectus	[illegible]
Pterygium	[illegible]
Pterygium, double	[illegible]
Septal resections	[illegible]
Drainage of highmore	1

Operations—Continued.

Eye, ear, nose, and throat operations—Con.	
Tonsilotomy with nasal adenectomy	10
Tonsilotomy	5
Tracheotomy	4
Cataract extraction	9
Cataract, needled	1
After cataract discission	4
Ligation vessels, interstitial keratitis	1
Mastoid	8
Frontal sinus	6
Plastic on face and nose	1
Plastic for ectropion	1
Plastic on nose	1
Plastic on ear	1
Plastic on lid	1
Tonotomy	4
Iridectomy	4
Ossiculectomy	1
Stricture lachrymal duct	3
Paracentesis	21
Furuncle	11
Enucleation of eye	6
Papilloma in nose removed	1
Uvulotomy	1
Eviscerations of eye	4
Cauterization of turbinate bones	4
Killani	1
Minor eye, ear, nose, and throat operations	360
Fractures:	
Skull	5
Skull with hemorrhage	1
Skull, compound	6
Spine	1
Femur, wired	3
Compound—	
Wired femur	9
Leg	1
Thigh	1
Inferior maxilla	1
Face bones	1
Wrist	1
Ankle	2
Arm	1
Humerus	1
Tibia and fibula	8
Carpals	1
Wired tibia	1
Small bones	1
Radius and ulna, wired	1
Fibromyema of breast	1
Fistula in ano	2
Hernia:	
Inguinal	119
Double	56
Double, with femoral hernia	1
Strangulated	3
Ventral	4
Femoral, strangulated	1
Hemorrhoids	41
Clamp and cautery	1
Whitehead	9
Clamp and ligature	16
Hydrocele	25
Double	3
Radical	5
Kidney, exploratory and decapsulation	1
Laparotomies, for—	
Abscess of liver	22
Multiple	1
Appendectomy	28
Appendectomy and salpingectomy	2
Blood cyst of spleen	1
Cholecystostomy	4
Cecostomy	7
Cecostomy for dysentery	2
Laparotomies, for—Continued.	
Colostomy, left inguinal	1
Cirrhosis of liver (Schiassi)	1
Colostomy, closure	1
Dudley's round ligament suspensio uteri	9
Round ligament suspensio uteri and appendectomy	6
Exploratory (hemorrhage)	2
Exploratory	4
Extra uterine pregnancy ruptured	1
Ectopic gestation	1
Gestation	1
Hysteromyomectomy	12
Hysterectomy and appendectomy	2
Hemorrhage, traumatic	1
Intestinal obstruction	1
Multiple gastric ulcers	1
Ovarian cystectomy	5
Pelvic inflammatory disease	2
Peritonitis—	
General—	
Appendical origin	2
Perforation, typhoid ulcer	1
Appendix	1
Ruptured intestines	1
Ecchinococcus	1
Tuberculosis	1
Traumatic	2
Chronic with fecal fistula	1
Local	3
Pelvic	1
Local appendix	4
Chronic adhesive	2
Peritonitis and appendectomy	1
Perityphlitis, chronic	1
Pelvic abscess	1
Ruptured spleen	1
Stab wound of abdomen	1
Salpingo-oophorectomy	1
Salpingo-oophorectomy and appendectomy	4
Salpingo-myomectomy and appendectomy	1
Subphrenic abscess	1
Ventral hernia	1
Oophorectomy and appendectomy	3
Laminectomy	2
Orchidectomy	4
Orchidectomy and lymphangitis	1
Osteomyelitis	3
Perineorrhaphy	8
Perineorrhaphy and trachelorrhaphy	5
Resection of—	
Knee	1
Rectum	1
Wrist (tuberculosis)	1
Suture of lung for traumatic hemorrhage	1
Skin graft	14
Stricture urethra:	
Internal operation	3
Perineal	4
Stricture of urethra	10
Trachelorrhaphy	9
Trachelorrhaphy and perineorrhaphy	1
Trephine for Jacksonian epilepsy	1
Thigh, stab wound into femoral vein	1
Urethrotomy:	
Perineal	6
Internal	10
Varicose veins	2
Varicose veins (Mayo)	4
Varicocele	14
Various major operations	150
Various minor operations	863
Total operations	2,431

Dispensary report.

Class.	White.	Colored.	Total.
Isthmian Canal Commission employees	560	1,556	2,116
Nonemployees	79	131	210
Total	639	1,687	2,326

Report of Colon Hospital.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining [illegible]
Isthmian Canal Commission employees	202	4,969	157	4,676	148	[illegible]
Panama R. R. employees	83	2,090	93	1,973	40	[illegible]
Ex-employees	30	47	7	70	0	[illegible]
Pay patients:						
Private	13	529	22	493	4	[illegible]
Municipal	16	454	90	351	3	[illegible]
Zone charity	19	303	58	241	6	[illegible]
Total	363	8,382	427	7,804	201	[illegible]

Average number of days' treatment per patient for the year	[illegible]
Average number of white employees constantly sick during year	[illegible]
Average number of black employees constantly sick during year	[illegible]
Average number of white and black employees constantly sick	[illegible]
Cost of subsistence per patient per day	[illegible]

Nationality.

Class.	Americans.		Other nations.		Number treated [illegible]
	White.	Colored.	White.	Colored.	
Isthmian Canal Commission employees	832	7	1,961	2,361	[illegible]
Panama R. R. employees	257	3	267	1,646	[illegible]
Ex-employees	13	0	12	52	[illegible]
Pay patients:					
Private	125	0	215	202	[illegible]
Municipal	10	4	84	372	[illegible]
Zone charity	33	0	70	219	[illegible]
Total	1,270	14	2,609	4,852	[illegible]

Ward laboratory report.

Blood examinations	8,764
Æstivo-autumnal	1,993
Tertian	1,087
Æstivo-autumnal and tertian	89
Double tertian	135
Widal reactions (positive 86)	577
Æstivo-autumnal and double tertian	5
Triple tertian	2
Spirillum obermeieri	30
Leucocyte counts	694
Erythrocyte counts	1
Filarial infections	98
Negative	2,589
Red blood counts	131
White blood counts	47
Differential counts	25
Differential leucocyte counts	173
Hæmoglobin estimations	16
Negative examinations	2,538
Guaiac-turpentine tests for invisible blood	295
Hæmoglobin determinations	2,352
Stool examinations	9,647
Ova of ascaris lumbricoides	784
Ova of ankylostomum duodenale	633
Ova of uncinaria	656
Ova of oxyuris vermicularis	1
Ova of schistosomum hæmotobium	6
Ova of tricocephalus dispar	2,047
Stool examinations—Continued	
Rhabdomena strongyloides	[illegible]
Cercomonas intestinalis	[illegible]
Monads	[illegible]
Negative examinations	[illegible]
Balantidium coli	[illegible]
Amœba coli	[illegible]
Pus and blood	[illegible]
Bacillus tuberculosis (positive 3)	[illegible]
Flagellated monads	[illegible]
Bilharzia	[illegible]
Sputum examinations	[illegible]
Positive for bacillus tuberculosis	[illegible]
Negative	[illegible]
Pneumococci	[illegible]
Positive	[illegible]
Urinalysis	[illegible]
Microscopical examinations	[illegible]
Albumen (negative, 6397)	[illegible]
Bence-Jones body, positive	[illegible]
Sugar	[illegible]
Negative	[illegible]
Diazo reactions	[illegible]
Positive	[illegible]
Hæmoglobin	[illegible]
Indican	[illegible]
Bile	[illegible]
Blood and pus	[illegible]
Bacillus tuberculosis (negative)	[illegible]

Pathological report.

Post-mortem examinations	409
Embalming	4
Celloidin sections examined	206
Post-mortem	892
Operative	218
Bacteriological examination of catgut (negative)	7
Wright's stain prepared (c. c.)	2,860
Cultures from splenic puncture (negative)	3
Paraffin sections:	
Post-mortem	733
Operative	60
Examination of:	
Exudates	[illegible]
Fetuses	[illegible]
Smears for treponema pallidium (positive, 1)	[illegible]
Gastric contents	[illegible]
Examination of stomach contents	[illegible]
Blood cultures	[illegible]
Miscellaneous	[illegible]
Lumbar punctures	[illegible]
Examination of smears for bacillus lepræ (negative)	[illegible]
Inoculation of guinea pig	[illegible]

Operations.

Abscess:	
Ventral	1
Psoas, lumbar incision	3
Ischio-rectal	2
Abscess, incised	7
Amputations:	
Leg—	
Upper one-third	1
Middle one-third	1
Lower one-third	2
Arm:	
Middle one-third	3
Lower one-third	3
Foot	1
Thigh—	
Middle one-third	1
Lower one-third	4
Thigh	1
Breast (Halstead's operation)	1
Disarticulation—	
Shoulder	2
At hip (Wyeth's operation)	2
Adenectomy:	
Inguinal glands	135
Cervical	7
Femoral	11
Supra-trochlear	1
Arthritis of knee incised and drained, septic	3
Curettage, uterine	14
Cellulitis of thigh and leg	4
Eye, ear, nose, and throat operations:	
Adenoids	1
Aural polypi removed	2
Abscess, lachrymal sac	1
Cataract extraction	5
Cataracts needled	15
Enucleation of eye	4
Evisceration of eye	3
Furuncle	1
Hæmatoma, auricle	1
Iridectomy	3
Mastoid	3
Myxomatous polypi removed	4
Nasal, polypi	14
Plastic for ectropion	3
Plastic on eye	1
Pterygium	14
Paracentesis	6
Membrana tympani	16
Of cornea	4
Of anterior chamber	4
Trachoma—	
Both eyes	1
Rolled	12
Expressions	2
Torsal tumors, incised and curetted	5
Tonsillectomy	10
Tonsillectomy and adenoids	5
Various others	271
Empyema, resection of ribs	19
Excision of fibro lipoma of chest	1
Fractures wired:	
Tibia	1
Clavicle	1
Ulva	1
Compound, right thigh	1
Fistula in ano	1
Herniotomy:	
Inguinal	76
Double	12
Strangulated	3
Umbilical	4
Ventral	3
Femoral	2
Hydrocele:	
Double, with scrotal resection	3
Radical	29
Hydrocele	22
Hemorrhoids:	
Whitehead's operation	27
Clamp and cautery	3
Laparotomies:	
Abscess of liver	22
Appendectomy	29
Appendostomy for dysentery	6
Amœbic perforation	2
Appendecostomy	1
Closure of fecal fistula	3
Cholecystostomy	3
Exploratory	15
Exploratory rupture of liver	1
Exploratory hepatotomy	2
Enterrorrhaphy for typhoid perforation	3
Gunshot wound of intestine and messentery	1
Gilliam's round ligament operation	1
Hysterectomy	2
Intestinal perforation—	
Typhoid	2
Amœbic	1
Lumbar nephrotomy for pyonephrosis	1
Ovariotomy	6
Oophorectomy, double	1
Peritonitis—	
General (amœbic)	1
General	2
Tuberculous	3
Pneumococcic	1
Pelvic adhesions	2
Pelvic adhesions and ventral suspension	1
Prolapse, both ovaries	1
Pelvic abscess	2
Panhysterectomy	2
Rupture of spleen	1
Rupture gastro-colic omentum	1
Round ligament suspension of uterus	3
Salpingo-oophorectomy	9
Salpingectomy, double and appendectomy	2
Sigmoidopexy	6
Splenectomy	1
Talma	1
Ventral suspension of uterus	2
Laminectomy	5
Laminectomy for fracture of spine	2
Orchidectomy	6
Osteomyelitis, tibia	3
Perineorrhaphy	18
Pneumonotomy	1
Pneumonorrhaphy	1
Repair of lacerated muscles of thigh	1
Repair of lacerated wounds of trachea and throat	1
Reduction of hip dislocation	1
Resection of elbow joint	1
Sequestrotomy for caries of inferior maxillæ	1
Sequestrotomy for caries of oscalcis	1
Skin graft	3
Stricture of rectum	1
Trephine for—	
Gunshot wound of skull	1
Intercranial hemorrhage	1
Fractured skull	3
Caries of calvarium	1
Thoracostomy for pyopneumothorax	1
Thoracostomy trauma	1
Throplasty, Schede's operation	1
Thyroidectomy	1
Urethrotomy:	
Perineal	16
Internal	18
Varicocele	26
Various major operations	66
Various minor operations	670
Total operations	1,825

Dispensary report.

Class.	White.	Colored.	Total.
Employees	3,521	3,420	[illegible]
Nonemployees	547	1,070	[illegible]
Total	4,068	4,490	[illegible]

REPORT OF PALO SECO LEPER ASYLUM.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Isthmian Canal Commission employees	0	2	0	1	0	[illegible]
Pay cases	10	7	0	0	0	[illegible]
Charity cases	1	1	0	0	0	[illegible]
Total	11	10	0	1	0	[illegible]

Average number of days treatment, per patient, for the year .... [illegible]
Average number of black employees constantly sick .... [illegible]
Cost of subsistence, per patient, per day .... $[illegible]

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	2	0	0	0	[illegible]
Pay cases	17	0	0	0	[illegible]
Charity cases	2	0	0	0	[illegible]
Total	21	0	0	0	[illegible]

REPORT OF TABOGA SANITARIUM.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	33	2,400	0	2,399	0	34
Children under 4 years (no pay)	0	46	1	45	0	[illegible]
Families of employees (pay patients)	7	580	0	587	0	[illegible]
Charity cases	0	1	0	1	0	[illegible]
Nonemployees (pay patients)	0	6	0	6	0	[illegible]
Total	40	3,033	1	3,038	0	34

Average number of days treatment, per patient, for the year .... [illegible]
Average number of white employees constantly sick .... [illegible]
Cost of subsistence, per patient, per day .... $0.[illegible]

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	2,433	1,660	0	773	0
Children under 4 years (no pay)	46	46	0	0	0
Families of employees (pay patients)	587	578	0	9	0
Charity cases	1	0	0	1	0
Nonemployees (pay patients)	6	6	0	0	0
Total	3,073	2,290	0	783	0

Report of Miraflores Hospital.

[Hospital in operation four months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	5	41	6	9	31	0
Ex-employees	25	12	2	25	10	0
Pay cases	67	55	7	99	16	0
Charity cases	22	26	7	24	17	0
Total	119	134	22	157	74	0

Average number of days treatment, per patient 8.97
Cost of subsistence, per patient, per day $0.257
Average number of employees constantly sick:
White 1.16
Colored 10.77
—— 11.93

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	46	0	0	9	37
Ex-employees	37	0	0	2	35
Pay cases	122	1	0	7	114
Charity cases	48	2	0	4	42
Total	253	3	0	22	228

Laboratory report.

Blood examinations	50	Urine examinations	73
Tertian	3	Albumen	12
Æstivo-autumnal	19	Casts	2
Negative	21	Negative	38
Stool examinations	9	Sputum examinations	11
Ascaris lumbricoides	2	Tubercle bacilli	7
Uncinaria ova	1	Post-mortem examinations	9
Negative	5		

Operations.

Amputation of leg 1
Minor operations 13

Dispensary report.

Class.	White.	Colored.	Total.
Employees	3,614	3,311	6,925
Nonemployees	24	68	92
Total	3,638	3,379	7,017

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	0	461	0	361	100	0

Average number of days treatment, per patient 3.04
Average number of employees daily sick in camp and quarters:
White 3.10
Colored 2.97

REPORT OF PARAISO HOSPITAL.

[Hospital in operation six months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 19[illegible]
Isthmian Canal Commission employees	7	342	5	300	44	[illegible]
Panama Railroad employees	0	10	1	6	3	[illegible]
Nonemployee	0	1	0	1	0	[illegible]
Total	7	353	6	307	47	[illegible]

Average number of days treatment, per patient .... [illegible]

Average number of employees constantly sick:
- White 3.61
- Colored 5.51

Cost of subsistence, per patient, per day .... $[illegible]

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	349	5	0	153	[illegible]
Panama Railroad employees	10	0	0	0	[illegible]
Nonemployee	1	0	0	0	[illegible]
Total	360	5	0	153	[illegible]

Laboratory report.

Urine examinations:
- Negative 10
- Epithaliæ casts 1
- Epithel cells 2
- Gonococcus 4
- Granulated casts 1
- Albumen 3
- Mucus 6
- Urethral discharge 10

Blood examinations:
- Aestivo-autumnal 92
- Tertian 30
- Negative 107

Stool examinations:
- Ankylostoma .... [illegible]
- Negative .... [illegible]
- Ascaris .... [illegible]
- Blood and mucus .... [illegible]
- Tricocephalus dispar .... [illegible]
- Pus and blood .... [illegible]
- Amœba dysenteria .... [illegible]

Sputum examinations:
- Negative .... [illegible]
- Tubercle bacilli .... [illegible]

Post-mortem examinations .... [illegible]

Operations.

Amputation of fingers .... 2 | Minor operations .... [illegible]

Dispensary report.

Class.	White.	Colored.	Total.
Isthmian Canal Commission employees	8,515	6,368	14,[illegible]
Panama Railroad employees	0	104	[illegible]
Nonemployees	1,012	689	1,[illegible]
Total	9,527	7,161	16,[illegible]

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 19[illegible]
Employees	12	2,991	2	2,822	170	[illegible]

Average number of days treatment, per patient .... [illegible]

Average number daily sick in camp and quarters:
- White .... [illegible]
- Colored .... 3.[illegible]

Report of Culebra Hospital.

[Hospital in operation six months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	36	419	12	405	38	0
Pay cases	0	2	0	2	0	0
Charity cases	1	5	2	4	0	0
Nonemployees	0	3	2	1	0	0
Total	37	429	16	412	38	0

Average number of days treatment, per patient, for the year 6.56

Average number of employees constantly sick:
White 9.64
Colored 7.66
17.30

Cost of subsistence, per patient, per day $0.338

Nationality.

Class.	Number treated.		Americans.		Other nations.	
	White.	Colored.	White.	Colored.	White.	Colored.
Employees	260	195	54	1	206	194
Pay cases	2	0	0	0	2	0
Charity cases	1	5	0	0	1	5
Nonemployees	0	3	0	0	0	3
Total	263	203	54	1	209	202

Operations.

Amputations:
- Leg 1
- Thigh 1
- Arm 2
- Hand 1

Laparotomy for perforation of intestines 1
Laparotomy for ruptured intestine 1
Laparotomy for lacerated wound of abdomen 1
Internal urethrotomy 1
Strangulated hernia 2
Inguinal hernia 1
Ventral hernia 1
Minor operations 836

Laboratory report.

Blood examinations 577
- Aestivo-autumnal 154
- Tertian 97
- Aestivo-autumnal and tertian 7
- Tertian, double 10
- Hæmoglobin estimates 6
- Leucocyte 3
- Negative 231

Urine examinations 531
- Albumen (negative, 295) 169
- Bile 6
- Microscopical examinations 9
- Sugar 0
- Diazo reactions, negative 2
- Pus and blood 3
- Albumen and casts 3

Stool examinations 116
- Negative 30
- Amœba coli 9
- Ova ascaris lumbricoides 5
- Amœba dysentery 4
- Blood and mucus 7
- Ova of uncinaria 22
- Ova of tricocephalus dispar 13
- Strongyloides 12
- Cercomonas intestinalis 6

Sputum examinations 26
- Negative 11
- Positive for tuberculosis bacilli 10
- Pus cells 1

Post-mortem examinations 15

Dispensary report.

Class.	White.	Colored.	Total.
Employees	26,610	13,152	39,762
Nonemployees	4,883	2,145	7,028
Total	31,493	15,297	46,790

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	3	2,577	4	2,246	302	[illegible]

Average number of days' treatment, per patient, in sick camp .... [illegible]

Average number daily sick in camp and quarters:
- White .... 9 [illegible]
- Colored .... 4 [illegible]

Report of Empire Hospital.

[Hospital section in operation four months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	12	322	1	265	68	[illegible]

Average number of days treatment, per patient, for the year .... [illegible]
Average number of white employees constantly sick .... [illegible]
Average number of black employees constantly sick .... [illegible]
Average number of white and black employees constantly sick .... [illegible]
Cost of subsistence, per patient, per day .... [illegible]

Nationality.

Class.	Number treated.	Americans.		Other nati[illegible]	
		White.	Colored.	White.	Co[illegible]
Employees	334	9	0	20[illegible]	[illegible]

Dispensary report.

Class.	White.	Colored.	Total.
Employees	39,656	18,019	[illegible]
Non-employees	87	65	[illegible]
Total	39,743	18,084	[illegible]

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Re[illegible]
Employees	8	4,161	1	4,084	67	[illegible]

Average number of days treatment, per patient, in sick camp .... [illegible]
Average number daily sick in camp and quarters:
- White 11.22
- Colored 6.22
- 17.[illegible]

REPORT OF LAS CASCADAS HOSPITAL.

[Hospital in operation three months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	13	205	2	195	21	0
Charity patients	0	4	1	2	1	0
Pay patients	0	1	0	0	1	0
Total	13	210	3	197	23	0

Average number of days treatment, per patient ... 6.02
Average number of employees constantly sick:
White ... 1.58
Colored ... .78
... 2.36
Cost of subsistence, per patient, per day ... $0.34

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	218	5	1	147	65
Charity patients	4	0	0	1	3
Pay patients	1	0	0	1	0
Total	223	5	1	149	68

Laboratory report.

Blood examinations ... 119
Negative ... 65
Aestivo-autumnal ... 22
Tertian ... 32
Stool examinations ... 9
Ankylostomia ... 2
Negative ... 7
Sputum examinations ... 11
Tubercle bacilli ... 1
Negative ... 10

Operations.

Disarticulation of left shoulder joint ... 1
Amputation, thigh ... 2

Dispensary report.

Class.	White.	Colored.	Total.
Employees	14,128	4,139	18,267
Nonemployees	1,808	923	2,731
Total	15,936	5,062	20,998

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	1	1,548	7	1,380	151	11

Average number of days treatment, per patient ... 2.04
Average number of employees daily sick in camp and quarters:
White ... 7.27
Colored ... 2.23
... 9.50

Report of Bas Obispo Hospital.

[Hospital in operation three months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	9	277	3	246	37	

Average number of days treatment, per patient .... [illegible]
Average number of employees constantly sick:
White .... [illegible]
Colored .... [illegible]

Cost of subsistence, per patient, per day .... $[illegible]

Nationality.

Class.	Number treated.		Americans.		Other [illegible]	
	White.	Colored.	White.	Colored.	White.	[illegible]
Employees	162	124	12	0	150	[illegible]

Laboratory report.

Blood examinations:
Tertian .... [illegible]
Aestivo-autumnal .... [illegible]
Negative .... [illegible]

Dispensary report.

Class.	White.	Colored.	To[illegible]
Employees	19,954	13,499	[illegible]
Nonemployees	753	353	[illegible]
Total	20,707	13,852	[illegible]

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	20	2,179	0	1,873	315	

Average number of days treatment, per patient .... [illegible]
Average number of employees daily sick in camp and quarters:
White 8.50
Colored 6.31

Report of Gorgona Hospital.

[Hospital in operation three months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	8	184	3	150	39	
Charity cases	0	7	3	4	0	
Total	8	191	6	154	39	

Average number of days treatment, per patient .... [illegible]
Average number of employees constantly sick:
White .... [illegible]
Colored .... [illegible]

Cost of subsistence, per patient, per day .... $[illegible]

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	192	8	0	57	127
Charity cases	7	0	0	0	7
Total	199	8	0	57	134

Laboratory report.

Blood examinations:	
Æstivo-autumnal	33
Tertian	15
Negative	57
Sputum examinations:	
Tubercle bacilli	1
Urine examinations	30
Albumen	20
Casts	2
Gonococci	3
Bile	5
Pus	8
Spermatozoa	1
Urine examinations—Continued.	
Negative	17
Uric acid	3
Stool examinations:	
Tricocephalus dispar	6
Uncinaria	6
Negative	11
Ankylostoma	2
Ascaris lumbricoides	5
Tricomonads	1
Pathological laboratory report:	
Post-mortem	2
Autopsy	1

Operations.

Amputations:	
Right thigh	1
Toe	1
Thumb	4
Leg	1
Finger	3
Fracture of right fibula	1
Fracture of tibia and fibula, right	1
Minor operations	52

Dispensary report.

Class.	White.	Colored.	Total.
Employees	19,591	11,879	31,470
Nonemployees	2,601	1,146	3,747
Total	22,192	13,025	35,217

Sick camp report.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	9	3,080	0	2,667	415	7

Average number of days treatment, per patient		1.24
Average number daily sick:		
White	5.62	
Colored	4.45	
		10.07

Report of Gatun Hospital.

[Hospital in operation three months of fiscal year.]

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	15	816	7	730	94	0
Nonemployees	0	2	1	0	1	0
Total	15	818	8	730	95	0

Average number of days treatment, per patient		3.70
Average number of employees constantly sick:		
White	20.60	
Colored	12.33	
		32.93
Cost of subsistence, per patient, per day		$0.22

Nationality.

Class.	Number treated.		Americans.		Other nat[illegible]	
	White.	Colored.	White.	Colored.	White.	Co[illegible]
Employees	511	320	31	1	480	[illegible]
Nonemployees	1	1	1	0	0	[illegible]
Total	512	321	32	1	480	[illegible]

Dispensary report.

Class.	White.	Colored.	T[illegible]
Employees	14,469	10,005	[illegible]
Nonemployees	1,484	185	[illegible]
Total	15,953	10,190	[illegible]

Sick camp report.

[Includes Spillway Camp.]

Class.	Remaining June 30 1907.	Admitted.	Died.	Discharged.	Transferred.	R[illegible]
Employees	5	3,130	1	2,732	380	[illegible]

Average number of days treatment, per patient .... [illegible]
Average number daily sick:
White 9.12
Colored 14.42
[illegible]

Report of Santo Tomas Hospital.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Re[illegible]
Isthmian Canal Commission employees	0	3	0	3	[illegible]
Panama R. R. employees	0	3	0	3	[illegible]
Pay cases	35	972	28	965	[illegible]
Charity cases	96	3,095	311	2,702	[illegible]
Total	131	4,073	339	3,673	[illegible]

Average number of days treatment, per patient .... [illegible]
Average number of Commission employees constantly sick .... [illegible]
Average number of nonemployees constantly sick .... [illegible]
Cost of subsistence, per patient, per day, $0.68 silver or $0.34 U. S. currency.

Nationality.

Class.	Number treated.	Americans.		Other natio[illegible]	
		White.	Colored.	White.	Colore[illegible]
Isthmian Canal Commission employees	3	0	0	2	[illegible]
Panama R. R. employees	3	2	0	0	[illegible]
Pay cases	1,007	9	0	331	[illegible]
Charity cases	3,191	72	2	770	[illegible]
Total	4,204	83	2	1,103	[illegible]

Operations.

Major operations .... [illegible]
Minor operations .... [illegible]

Dispensary report.

Class.	White.	Colored.	Total.
Natives	257	864	1,121
Foreigners	164	338	502
Total	421	1,202	1,623

REPORT OF PEDRO MIGUEL DISPENSARY AND SICK CAMP.

Dispensary.

Class.	White.	Colored.	Total.
Employees	6,719	2,556	9,275
Nonemployees	558	424	982
Total	7,277	2,980	10,257

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	4	923	0	772	145	10

Average number of days treatment, per patient 4.23

Average number of employees sick daily:

White 8.48

Colored 4.06

—— 12.54

REPORT OF SAN PABLO DISPENSARY AND SICK CAMP.

[Sick camp in operation eight months of fiscal year.]

Dispensary.

Class.	White.	Colored.	Total.
Employees	4,492	3,896	8,388
Nonemployees	56	254	310
Total	4,548	4,150	8,698

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	0	506	1	434	67	4

Average number of days treatment, per patient 1.82

Average number of employees sick daily:

White 2.68

Colored 1.37

—— 4.05

REPORT OF PORTO BELLO DISPENSARY AND SICK CAMP

[In operation five months of fiscal year.]

Dispensary.

Class.	White.	Colored.	Total.
Employees	4,924	3,168	8,092
Nonemployees	9	161	170
Total	4,933	3,329	8,262

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	6	1,386	0	986	397	[illegible]

Average number of days' treatment, per patient .... [illegible]
Average number of employees sick daily:
White .... 5.[illegible]
Colored .... 4.[illegible]
[illegible]

Report of Cristobal Dispensary and Sick Camp.

Dispensary.

Class.	White.	Colored.	Total.
Employees	12,273	7,769	[illegible]
Nonemployees	2,938	670	[illegible]
Total	15,211	8,439	[illegible]

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	5	907	0	761	140	[illegible]

Average number of days' treatment per patient .... [illegible]
Average number daily sick:
White 6.14
Colored 8.43
14.[illegible]

Report of Tivoli Dispensary and Sick Camp.

Dispensary.

Class.	White.	Colored.	Total.
Employees	4,589	4,806	[illegible]
Nonemployees	989	394	[illegible]
Total	5,578	5,200	[illegible]

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	[illegible]
Employees	0	2,621	0	2,576	40	[illegible]

Average number of days' treatment per patient .... [illegible]
Average number of employees constantly sick:
White 3.74
Colored .... 3.[illegible]
[illegible]

Report of La Boca Dispensary and Sick Camp.

Dispensary.

Class.	White.	Colored.	Total.
Employees	14,148	11,287	[illegible]
Nonemployees	585	596	[illegible]
Total	14,733	11,883	[illegible]

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	11	3,292	0	3,109	187	7

Average number of days' treatment per patient 0.87
Average number of employees constantly sick:
White 6.54
Colored 3.34
—— 9.88

Report of Taberanilla Dispensary and Sick Camp.

Dispensary.

Class.	White.	Colored.	Total.
Employees	7,971	12,196	20,167
Nonemployees	333	440	773
Total	8,304	12,636	20,940

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	7	2,726	1	1,972	751	9

Average number of days' treatment per patient 1.91
Average number of employees constantly sick:
White 3.52
Colored 9.46
—— 12.98

Report of Corozal Dispensary and Sick Camp.

Dispensary.

Class.	White.	Colored.	Total.
Employees	6,613	3,947	10,560
Nonemployees	592	313	905
Total	7,205	4,260	11,465

Sick camp.

Class.	Remaining June 30, 1907.	Admitted.	Died.	Discharged.	Transferred.	Remaining June 30, 1908.
Employees	2	1,354	0	1,026	330	0

Average number of days' treatment per patient 1.82
Average number of employees constantly sick:
White 3.95
Colored 2.23
—— 6.18

Report of Board of Health Laboratory.

Bacteriological examination of—	
Municipal water supplies	496
Water from filters	1
Water from Rio Grande (special)	18
Water from springs	3
Water from tanks	3
Water from condensers	215
Water from tank carts and demijohns	197
Water from Palo Seco	1
Water from coolers	4
Water from rivers	49
Rain water	1
Water from cold storage, Cristobal	2
Ice	1
Milk	1
Caramel (sarsaparilla)	2
Pus	12
Carbonated soda water	27
Aerated waters	44
Exudates	20
Blood cultures	250
Charcoal filter	1
Glanders suspect (negative)	1
Animal from chief quarantine officer	1
Throat cultures	2
Blood filtrate	1
Phenol sodique	1
Flour	1
Cultures from autopsies	26
Chemical and bacteriological examination of—	
Milk	5
Flour	1
Canned rhubarb	1
Agglutination reactions	1,783
Positive	230
Chemical analyses of—	
Milk	3
Wine	1
Condensed milk	2
Fussell's brand sterilized milk and cream	2
Flour	1
Linseed oil	1
Lard oil	20
Turpentine	12
Evaporated milk	1
Bay rum	1
Malted milk	2
Rum	2
Babbitt metal	4
Wire screening	3
Rock	1
"Meatox"	1
Chemical examination of—	
Urine	2
Wire screening	1
Stomach contents	4
Milk from Ancon dairy	4
Breakfast sirup	1
Powder	1
Phinotas oil	1
Mineral oil	2
Jams	2
Paints	3
Dynamite exploders	1
Flavoring extracts	1
Gasoline	1
Sanitary analyses of—	
Water	2
Water from Colon	1
Sanitary analyses of—Continued.	
Water from Brazos Brook	
Water from Gorgona	
Water from Comacho	
Water from Rio Grande	
Water from Mindi	
Water from Paraiso	
Water from Gatuncillo River	
Assay of—	
Graphite	
Formaldehyde	
Hydrocyanic acid	
Alum	
Kerosene	
Magnesia cement	lo[illegible]
Determination of—	
Chlorine in water	
Total solids in water	
Specific gravity of rock	
Salicylic acid in urine	
Hardness in La Boca water	
Preservatives in aerated waters	
Examination of—	
Coffee	
Rat	
Rat poison	
Stomach contents	
Stools for tubercle bacilli	
Sputum for tubercle bacilli	
Bean seedlings	lo[illegible]
Urine	
Blood	
Leper suspects	
Positive	
Pus	
Sputum	
Sewage	
Stools	
Phinotas oil	
Powder	
Cows for tuberculosis (negative)	
Blood for spirochetes	
Quinine urea tablets	
Rock	
Pathological tissues	
Maple sugar sirup	
Toxicological examination of stomach contents	
Aerated waters for preservatives	
Mosquitoes for identification	lots
Tissues and neoplasms reported	
Celloidin and paraffin sections cut	
Celloidin sections cut	
Pathological sections cut	
Frozen sections cut	
Medico-legal examinations	
Sections of tissue prepared	
Autopsies	
Bodies embalmed	
Post-mortem examination of calf	
Preparation of sodum citrate (5,000).	
Preparation of absolute alcohol (1,000 c. c.)	
Rectification of anilin oil (1,000 c. c.).	
Standardisation of clinical thermometers. lots	
Preventive treatment of persons bitten by rabid dogs	
Examination of rabies suspects (dogs)	

Report of vaccinations.

Panama	3,186
Colon	624
Matachin	40
Taboga	111
Empire	320
Pedro Miguel	44
Corozal	72
Gorgona	242
Paraiso	52
La Boca	39
Gatun	187
Tabernilla	40
San Pablo	68
Matachin	
Las Cascadas	
Cristobal	
Bohio	
Culebra	
Porto Belle	
Las Sabanas	
Vaccinations by quarantine officials at ports of Panama and Colon, and vaccinations at ports of departure or en route	
Total vaccinations	

Statement of issues of quinine.

[Kilo=2.2046 pounds avoirdupois.]

Total issues.	Kilo.	Pounds avoirdupois.
1907.		
July	15.157	33.157
August	137.000	299.688
September	86.444	189.971
October	269.551	589.643
November	134.887	295.065
December	17.251	37.737
1908.		
January	274.933	601.416
February	57.500	125.781
March	15.225	32.353
April	68.871	150.655
May	48.600	106.312
June	36.681	80.241
Total	1,162.100	2,542.019
Average issue per month	96.842	211.835

General sanitation, city of Panama.

Street cleaning and garbage collection:	
Daily average number of men at work	57
Daily average number of carts at work	16
Total number of loads of garbage removed	4,573
Total number of loads of sweepings removed	1,465
Catch basins disinfected ... times	8,055
Results of inspections of yards:	
Houses with water connection ... times inspected	24,966
Houses with no water connection ... do	4,020
Houses with sewer connection ... do	24,074
Houses with no sewer connection ... do	4,693
Traps in yards, connected with sewer ... do	23,588
Traps in yards, not connected with sewer ... do	3,909
Wells on premises ... do	518
Tanks on premises ... do	172
Water containers destroyed	5,042
Water-closets, good condition ... times inspected	23,581
Water-closets, bad condition ... do	3,161
Yards, drainage good ... do	23,305
Yards, bad drainage ... do	3,736
Persons notified to keep premises in good sanitary condition and to connect with water and sewer	810
Persons notified to connect with water and sewer	35
Persons notified to keep their premises in sanitary condition	1,344
Persons notified as to the insanitary condition of yards	3,280
Persons fined by local authorities for insanitary condition of yards	7
Places where mosquito larvæ were found	5,142
Persons warned for having mosquito larvæ	2,853
Persons fined by local authorities for having mosquito larvæ	16
Anopheles brigade:	
Number of linear feet of ditches cleaned	839,420
Number of linear feet of ditches dug	7,075
Weeds and grass cut ... square feet	1,440,879
Number of linear feet of drains cleaned and disinfected	30,600
Wells filled	68
Earth used ... cubic yards	5,991
Closets oiled	699
Drains oiled	3
Cesspools oiled	149
Pools oiled	22,936
Sewers oiled	17
Chloride of lime used ... pounds	340
Trenches oiled	1,851
Linear feet of trenches oiled	312,900
Tanks oiled	24
Traps oiled	2
Carbolic acid used ... barrels	2
Wells oiled	97
Pools oiled	182
Yards oiled	3,952
Holes filled	1,209
Ponds filled	1
Mosquito oil used ... barrels	345.5
Loads of refuse removed	3,820
Daily average number of carts at work	7
Number of days carts worked	300

Tank and gutter removal:		
Number of tanks removed		[illegible]
Number of barrels removed		[illegible]
Total capacity of tanks removed	gallons	[illegible]
Disinfection brigade (for pneumonia, tuberculosis, and beriberi):		
Number of houses disinfected		[illegible]
Number of houses fumigated		[illegible]
Number of rooms disinfected		[illegible]
Number of rooms fumigated		[illegible]
Number of cubic feet disinfected		[illegible]
Number of cubic feet fumigated		[illegible]
Number of houses demolished		[illegible]
Material used—		
Alcohol	gallons	[illegible]
Bichloride of mercury	pounds	[illegible]
Formaldehyde	gallons	
	pints	
Flour	barrels	
	pounds	[illegible]
Pyrethrum	do	[illegible]
Matches	packages	[illegible]
Newspapers—		
Bundles		[illegible]
Pounds		[illegible]
Sulphur	pounds	[illegible]
Chloride of lime	do	[illegible]
Destruction of rats:		
Number of rats caught and cremated		[illegible]
Number of rat traps distributed		[illegible]
Number of traps in use		[illegible]
Bait used	pounds	[illegible]
Rat poison used	do	[illegible]
Bread used	do	[illegible]
Cheese used	do	[illegible]
Ham used	do	[illegible]
Destruction of dogs:		
Number of dogs poisoned		14
Poison used, strychnine	ounce	1
Ham used	pounds	
Beef used	do	3
Sick inspection:		
Hotels and boarding houses inspected		[illegible]
Persons reported ill		[illegible]
Urinary analyses made, (all negative)		4
New buildings, plans submitted to the health officer and approved		[illegible]

Sanitation, Colon (including Cristobal and Mount Hope).

Medical inspection:	
Cases reported to health officer by medical inspector	[illegible]
Cases inspected by health office physician	[illegible]
Cases sent to Colon Hospital	[illegible]
White employees reported to health officer	[illegible]
White employees inspected by health office physician	[illegible]
Number of smallpox cases reported	[illegible]
Cases reported (colored) and sent to dispensary from Camp Bierd	[illegible]
Quinine (prophylactic) dispensed to laborers:	
Total number of tablets (5 grain) dispensed	[illegible]
Total doses (ounces), 5 grains to ounce, dispensed	[illegible]
Average number of doses, tablets, dispensed daily	[illegible]
Average number of doses, solution, dispensed daily	[illegible]
Sanitation of Cristobal:	
Cans of garbage removed	[illegible]
Loads of yard garbage carted	[illegible]
Cans of night soil removed	[illegible]
Miscellaneous loads carted	[illegible]
Loads of dirt carted	[illegible]
Loads from storehouse	[illegible]
Square yards of street cleaned	[illegible]
Tanks removed	[illegible]
Square yards of street sprinkled	[illegible]
House screens repaired	[illegible]
Stegomyia mosquito brigade (Cristobal):	
Square yards of vegetation removed	[illegible]
Water receptacles overturned	[illegible]
Water receptacles collected	[illegible]
Linear feet of drains cleaned	[illegible]
Number of feet of gutters cleaned	[illegible]
Number of feet of new drains made	[illegible]
Pools oiled	[illegible]
Square yards of pools oiled	[illegible]
Tanks oiled	[illegible]
Linear feet of drain oiled	[illegible]
Linear feet of drain filled in	[illegible]
Tanks overturned	[illegible]
Square yards of lagoon cleaned	[illegible]

a Beginning October 1 serious or suspicious cases only visited by health office physician.

Stegomyia mosquito brigade (Cristobal)—Continued.	
Square yards of lagoon filled	50
Number of crab holes oiled	132,661
Number of crab holes worked	25,730
Number of breeding places eradicated	277
Number of crabs killed	4,516
Number of tanks removed	70
Number of barrels covered	3
Ash cans installed	16
Rats caught	4
Fumigation of Cristobal:	
Houses fumigated	20
Number of cubic feet fumigated	546,286
Sanitation of Mount Hope:	
Number of cans of garbage removed	29,658
Number of cans of night soil removed	25,403
Number of square yards of vegetation removed	295,551
Miscellaneous loads carted	659
Number of square yards of lagoon cleaned	1,757
Number of loads of yard garbage removed	229
Number of square yards of street cleaned	37,139
Number of houses fumigated	1
Stegomyia mosquito brigade (Mount Hope):	
Water receptacles overturned	32,166
Water receptacles collected	65,475
Breeding places eradicated	947
Tanks oiled	5,462
Square yards of pools oiled	429,527
Barrels covered	177
Square yards of street cleaned	6,600
Barrels spigoted	67
Square yards of lagoon cleaned and filled	2,400
Square yards of lagoon cleaned only	2,064
Square yards of lagoon filled only	2,458
Square yards of vegetation removed	2,976,384
Number of feet of drainage made	49,429
Number of feet of drain cleaned	67,163
Sanitation of Mount Hope Cemetery:	
Square yards of vegetation removed	423,844
Linear feet of drain made	1,446
Number of graves graded	80
Number of graves dug	585
Number of interments	726
Linear feet of drain cleaned	508
Shrubs planted	40
Posts removed	120
Stumps removed	56
Trees cut	37
Square yards of grading and filling	320
Square yards of grading made	7,961
Grave markers painted	2,045
Disinterments	3
Sanitation of Colon:	
Cans of garbage removed	875,482
Loads of yard garbage carted	2,197
Cans of night soil removed	453,072
Miscellaneous loads carted	861
Square yards of street cleaned	9,824,987
Cesspools cleaned	68
Cesspools filled	12
Tanks removed	169
Night-soil cans installed	92
Night-soil cans retired	1,254
Loads to and from storehouse	50
Loads of lumber carted	315
Water-closets cleaned	209
Houses condemned and demolished	24
Yards cleaned	284
Passages cleaned	78
Buildings cleaned	21
Water-closets torn down	22
Private lots cleaned	385
Nuisances reported	862
Notices served	1,278
Nuisances abated	1,124
Cars of dirt unloaded	917
Linear feet of drain cleaned	3,436,260
Linear feet of ditches made	1,230
Rats caught and killed	3,747
Houses cleaned	171
Square yards of pools oiled	8,390
Water receptacles treated	22,900
Dogs killed	100
Cars fumigated	1
All yards in Colon inspected.	
Bolivar street tracks cleaned daily.	
Stegomyia mosquito brigade (Colon):	
Water receptacles collected	141,813
Water receptacles overturned	10,896
Square yards of pools oiled	32,934

Stegomyia mosquito brigade (Colon)—Continued.

Tanks oiled	[illegible]
Breeding places eradicated	[illegible]
Linear feet of new drain made	[illegible]
Number of feet of drain cleaned	[illegible]
Barrels destroyed	[illegible]
Barrels covered	[illegible]
Square yards of vegetation removed	[illegible]
Sags removed	
Crab holes oiled	[illegible]
Crab holes worked	[illegible]
Crabs killed	[illegible]
Number of feet of gutters removed	[illegible]
Number of persons fined	
Persons fined by alcalde for mosquito breeding	
Cars of dirt received	[illegible]
Sanitation of Porto Bello:	
Cans of garbage removed	[illegible]
Loads of yard garbage carted	[illegible]
Square yards of vegetation removed	[illegible]
Crab holes worked	[illegible]
Crabs killed	[illegible]
Linear feet of drain cleaned	[illegible]
Square yards of pools oiled	[illegible]
Linear feet of new drains made	[illegible]
Water receptacles overturned	
Breeding places eradicated	[illegible]
Houses:	
Number of plans approved	[illegible]
Permits issued to occupy	[illegible]
Condemned	
Demolished	

Sanitation, Canal Zone.

Ancon:		
Swamp filled in	cubic yards	[illegible]
Swamp drained	do	[illegible]
Grass cut and removed	square yards	[illegible]
Tile drain laid	linear feet	[illegible]
New ditches stoned and cemented	do	[illegible]
New ditches dug	do	[illegible]
Old ditches cleaned and graded	do	[illegible]
Brush cut and removed	square yards	[illegible]
Old ditches stoned and cemented	linear feet	[illegible]
Closets cared for	daily	[illegible]
Garbage cans emptied	do	[illegible]
Closet pits filled in (1)	cubic yards	
Night-soil cans emptied	daily	[illegible]
Houses disinfected		[illegible]
Closets erected		
Closet pits dug (4)	cubic yards	
Houses fumigated (11)	cubic feet	[illegible]
Metallic screen repaired	houses	[illegible]
Ground prepared for use of mower	square yards	[illegible]
La Boca:		
Swamp filled in	cubic yards	[illegible]
Swamp drained	do	[illegible]
Grass cut and removed	square yards	[illegible]
Tile drain laid	linear feet	[illegible]
New ditches stoned and cemented	do	[illegible]
New ditches dug	do	[illegible]
Old ditches cleaned and graded	do	[illegible]
Brush cut and removed	square yards	[illegible]
Closets cared for	daily	[illegible]
Garbage cans emptied	do	[illegible]
Closet pits filled in (6)	cubic yards	[illegible]
Night-soil cans emptied	daily	[illegible]
Houses disinfected		
Closets erected		[illegible]
Closet pits dug (15)	cubic yards	[illegible]
Houses fumigated (21)	cubic feet	[illegible]
Metallic screen repaired	houses	[illegible]
Ground prepared for use of mower	square yards	[illegible]
Ponds drained	do	[illegible]
New stone, cement, and concrete ditches laid	linear feet	[illegible]
New ditches cleaned and cemented	do	[illegible]
Corozal:		
Swamp filled in	cubic yards	[illegible]
Swamp drained	do	[illegible]
Grass cut and removed	square yards	[illegible]
Tile drain laid	linear feet	[illegible]
New ditches dug	do	[illegible]
Old ditches cleaned and graded	do	[illegible]
Brush cut and removed	square yards	[illegible]
Closets cared for	daily	[illegible]
Garbage cans emptied	do	[illegible]
Closet pits filled in (12)	cubic yards	[illegible]
Night-soil cans emptied	daily	
Houses disinfected		

Corozal—Continued.		
Closets erected		20
Closet pits dug (30)	cubic yards	151
Houses fumigated (42)	cubic feet	700,647
Metallic screen repaired	houses	445
Ponds drained	square yards	27,770
Miraflores:		
Swamp drained	cubic yards	3,014
Grass cut and removed	square yards	145,540
Tile drain laid	linear feet	7,507
New ditches dug	do	921
Old ditches cleaned and graded	do	134,839
Brush cut and removed	square yards	5,531
Closets cared for	daily	22
Garbage cans emptied	do	51
Closet pits filled in		1
Night-soil cans emptied	daily	30
Closets erected		34
Closet pits dug (54)	cubic yards	226
Houses fumigated (4)	cubic feet	4,000
Metallic screen repaired	houses	1
Ponds drained	square yards	600
Pedro Miguel:		
Swamp filled in	cubic yards	16,759
Swamp drained	do	600
Grass cut and removed	square yards	452,088
Tile drain laid	linear feet	2,502
New ditches stoned and cemented	do	235
New ditches dug	do	8,318
Old ditches cleaned and graded	do	91,616
Brush cut and removed	square yards	466,486
Old ditches stoned and cemented	linear feet	90
Closets cared for	daily	95
Garbage cans emptied	do	243
Closet pits filled in (73)	cubic yards	118
Night-soil cans emptied	daily	90
Houses disinfected		5
Closets erected		19
Closet pits dug (67)	cubic yards	229
Houses fumigated (29)	cubic feet	164,524
Metallic screen repaired	houses	228
Ponds drained	square yards	8,442
Paraiso:		
Swamp filled in	cubic yards	909
Grass cut and removed	square yards	1,885,851
Tile drain laid	linear feet	7,204
New ditches dug	do	10,198
Old ditches cleaned and graded	do	145,753
Brush cut and removed	square yards	74,838
Closets cared for	daily	78
Garbage cans emptied	do	212
Closet pits filled in (28)	cubic yards	119
Night-soil cans emptied	daily	66
Houses disinfected		3
Closets erected		6
Closet pits dug (45)	cubic yards	364
Houses fumigated (13)	cubic feet	108,742
Metallic screen repaired	houses	309
Ponds drained	square yards	50
Cucaracha:		
Grass cut and removed	do	120,722
Tile drain laid	linear feet	756
New ditches dug	do	3,816
Old ditches cleaned and graded	do	64,687
Brush cut and removed	square yards	54,518
Closets cared for	daily	209
Garbage cans emptied	do	52
Night-soil cans emptied	do	3
Houses disinfected		1
Culebra:		
Swamp filled in	cubic yards	1,236
Grass cut and removed	square yards	1,963,639
Tile drain laid	linear feet	18,885
New ditches dug	do	19,419
Old ditches cleaned and graded	do	161,406
Closets cared for	daily	40
Garbage cans emptied	do	735
Closet pits filled in (13)	cubic yards	23
Night-soil cans emptied	daily	80
Houses disinfected		11
Closets erected		2
Closet pits dug (15)	cubic yards	72
Houses fumigated (15)	cubic feet	298,281
Metallic screen repaired	houses	603
Ground prepared for use of mower	square yards	140,331
New stone, cement, and concrete ditches laid	linear feet	5,591
Empire:		
Swamp filled in	cubic yards	8,[illegible]
Swamp drained	do	[illegible]
Grass cut and removed	square yards	

Empire—Continued.	
Tile drain laid	linear feet
New ditches dug	do
Old ditches cleaned and graded	do
Brush cut and removed	square yards
Closets cared for	daily
Garbage cans emptied	do
Closet pits filled in (36)	cubic yards
Night-soil cans emptied	daily
Houses disinfected	
Closets erected	
Closet pits dug (42)	cubic yards
Houses fumigated (23)	cubic feet
Metallic screen repaired	houses
Ground prepared for use of mower	square yards
Las Cascadas:	
Swamp filled in	cubic yards
Swamp drained	do
Grass cut and removed	square yards
Tile drain laid	linear feet
New ditches stoned and cemented	do
New ditches dug	do
Old ditches cleaned and graded	do
Brush cut and removed	square yards
Old ditches stoned and cemented	linear feet
Closets cared for	daily
Garbage cans emptied	do
Closet pits filled in (43)	cubic yards
Night-soil cans emptied	daily
Houses disinfected	
Closets erected	
Closet pits dug (60)	cubic yards
Houses fumigated (19)	cubic feet
Metallic screen repaired	houses
New stone, cement, and concrete ditches laid	linear feet
Bas Obispo:	
Swamp filled in	cubic yards
Grass cut and removed	square yards
Tile drain laid	linear feet
New ditches dug	do
Old ditches cleaned and graded	do
Brush cut and removed	square yards
Closets cared for	daily
Garbage cans emptied	do
Closet pits filled in (110)	cubic yards
Night-soil cans emptied	daily
Houses disinfected	
Closets erected	
Closet pits dug (101)	cubic yards
Houses fumigated (47)	cubic feet
Metallic screen repaired	houses
Ponds drained	square yards
New stone, cement, and concrete ditches laid	linear feet
Matachin:	
Swamp filled in	cubic yards
Swamp drained	do
Grass cut and removed	square yards
Tile drain laid	linear feet
New ditches dug	do
Old ditches cleaned and graded	do
Brush cut and removed	square yards
Closets cared for	daily
Garbage cans emptied	do
Closet pits filled in (24)	cubic yards
Night-soil cans emptied	daily
Closets erected	
Closet pits dug (32)	cubic yards
Houses fumigated (9)	cubic feet
Metallic screen repaired	houses
Gorgona (including Mamei):	
Swamp filled in	cubic yards
Swamp drained	do
Grass cut and removed	square yards
Tile drain laid	linear feet
New ditches stoned and cemented	do
New ditches dug	do
Old ditches cleaned and graded	do
Brush cut and removed	square yards
Old ditches stoned and cemented	linear feet
Closets cared for	daily
Garbage cans emptied	do
Closet pits filled in (23)	cubic yards
Night-soil cans emptied	daily
Houses disinfected	
Closets erected	
Closet pits dug (31)	cubic yards
Houses fumigated (18)	cubic feet
Metallic screen repaired	houses
New stone, cement, and concrete ditches laid	linear feet

San Pablo:		
Swamp filled in	cubic yards	3,631
Grass cut and removed	square yards	888,669
Tile drain laid	linear feet	93
New ditches dug	do	17,167
Old ditches cleaned and graded	do	68,047
Brush cut and removed	square yards	188,924
Closets cared for	daily	39
Garbage cans emptied	do	100
Closet pits filled in (65)	cubic yards	97
Night-soil cans emptied	daily	21
Houses disinfected		1
Closets erected		40
Closet pits dug (102)	cubic yards	297
Houses fumigated (17)	cubic feet	138,067
Metallic screen repaired	houses	180
Ponds drained	square yards	1,000
Tabernilla:		
Swamp filled in	cubic yards	1,698
Grass cut and removed	square yards	1,984,022
Tile drain laid	linear feet	9,040
New ditches dug	do	30,135
Old ditches cleaned and graded	do	172,258
Brush cut and removed	square yards	33 058
Closets cared for	daily	47
Garbage cans emptied	do	227
Closet pits filled in (50)	cubic yards	77
Night-soil cans emptied	daily	44
Houses disinfected		9
Closets erected		12
Closet pits dug (69)	cubic yards	221
Houses fumigated (60)	cubic feet	1,371,727
Metallic screen repaired	houses	89
Ponds drained	square yards	230
New stone, cement, and concrete ditches laid	linear feet	839
Bohio:		
Swamp filled in	cubic yards	150
Grass cut and removed	square yards	132,916
Old ditches cleaned and graded	linear feet	127,175
Brush cut and removed	square yards	7,110
Closets cared for	daily	60
Garbage cans emptied	do	75
Closet pits filled in (25)	cubic yards	72
Night-soil cans emptied	daily	11
Closets erected		25
Closet pits dug (44)	cubic yards	200
Houses fumigated (21)	cubic feet	91,372
Metallic screen repaired	houses	45
Gatun:		
Swamp filled in	cubic yards	15,789
Swamp drained	do	2,230
Grass cut and removed	square yards	883,394
Grass cut and burned	do	717,192
Brush cut and removed	do	336,980
Tile drain laid	linear feet	26,292
New ditches stoned and cemented	do	1,330
New ditches dug	do	15,603
Old ditches cleaned and graded	do	77,041
Closets cared for	daily	75
Garbage cans emptied	do	347
Closet pits filled in (105)	cubic yards	218
Night-soil cans emptied	daily	23
Houses disinfected		10
Closets erected		37
Closet pits dug (157)	cubic yards	598
Houses fumigated (12)	cubic feet	158,242
Metallic screen repaired	houses	380
Ponds drained	square yards	150
Porto Bello:		
Swamp filled in	cubic yards	85
Grass cut and removed	square yards	211,476
Tile drain laid	linear feet	1,615
New ditches dug	do	1,136
Old ditches cleaned and graded	do	14,732
Closets cared for	daily	13
Garbage cans emptied	do	54
Night-soil cans emptied	do	20
Closets erected		10
Recapitulation:		
Swamp filled in	cubic yards	115,878
Swamp drained	do	85,064
Grass cut and removed	square yards	25,308,045
Grass cut and burned	do	717,192
Brush cut and removed	do	2,072,689
Tile drain laid	linear feet	132,224
New ditches stoned and cemented	do	14,739
New ditches dug	do	238,979
Old ditches cleaned and graded	do	2,437,004
Old ditches stoned and cemented	do	1,635

Recapitulation—Continued.

Closets cared for	daily	[illegible]
Garbage cans emptied	do	[illegible]
Closets pits filled in (615)	cubic yards	[illegible]
Night-soil cans emptied	daily	[illegible]
Houses disinfected		[illegible]
Closets erected		[illegible]
Closets pits dug (868)	cubic yards	[illegible]
Houses fumigated (361)	cubic feet	5,[illegible]
Metallic screen repaired	houses	[illegible]
Ground prepared for use of mower	square yards	[illegible]
Ponds drained	do	[illegible]
New stone, cement, and concrete ditches laid	linear feet	[illegible]
New ditches cleaned and cemented	do	[illegible]

Sanitation, Bocas del Toro.

General cleaning:	
Barrels of garbage removed	1[illegible]
Loads of yard garbage removed	[illegible]
Square yards of street cleaned	44[illegible]
Number of loads of sand carted	[illegible]
Daily average number of men at work	[illegible]
Loads of garbage removed from beach	[illegible]
Yards of water front cleaned	1,[illegible]
Closets oiled	[illegible]
Water-closets cleaned	[illegible]
Number of yards cleaned	[illegible]
Loads of old lumber carted	[illegible]
Miscellaneous loads carted	[illegible]
Linear feet of board walks made	[illegible]
Linear feet of board walks repaired	[illegible]
Cesspools filled	[illegible]
Loads of street sweepings removed	[illegible]
Houses torn down	[illegible]
Square yards of street repaired	[illegible]
Linear feet of drainpipe laid	[illegible]
Nuisances reported	[illegible]
Nuisances abated	[illegible]
Trees cut down	[illegible]
Stumps removed	[illegible]
Vacant lots cleaned	[illegible]
Persons notified to keep yards in sanitary condition	[illegible]
Mosquito brigade:	
Number of square yards of grass cut and removed	17[illegible]
Barrels repaired	1,[illegible]
Barrels covered	[illegible]
Barrels spigoted	1,[illegible]
Wells filled	[illegible]
Wells cleaned	[illegible]
Barrels overturned	1,4[illegible]
Barrels destroyed	[illegible]
Tanks destroyed	[illegible]
Tanks repaired	[illegible]
Barrels oiled	[illegible]
Wells oiled	[illegible]
Tanks oiled	[illegible]
Crab holes worked	26[illegible]
Crab holes filled	[illegible]
Crabs killed	[illegible]
Water receptacles collected	3[illegible]
Number of linear feet of drainage made	2[illegible]
Number of linear feet of drain cleaned	11,[illegible]
Number of hours oiling	[illegible]
Number of hours reinspection of barrels and tanks	[illegible]
Number of persons fined	[illegible]
Square yards of vegetation removed	8,[illegible]
Square yards of pools oiled	1,[illegible]
Breeding places eradicated	[illegible]
Square yards of brush cut	34,[illegible]
Square yards of swamps drained	[illegible]
Square yards of swamps filled	[illegible]
Catch-basins oiled	[illegible]
Gutters repaired	[illegible]
Gutters removed	1
Materials used:	
Spigots	1,[illegible]
Number of feet of copper-wire screening	2,[illegible]
Number of barrels of mosquito oil	[illegible]
Number of pounds of chloride of lime	[illegible]
Number of pounds of bichloride of mercury	4

Quarantine service, ports of Ancon, Panama, Colon, and Cristobal.

umber of vessels inspected and passed	947
umber of vessels detained in quarantine	9
umber of vessels fumigated on arrival	18
umber of vessels fumigated prior to sailing	72
umber of pieces of baggage disinfected	2,180
tal number of crew inspected	66,964
tal number of passengers inspected	62,454
tal number of persons inspected	129,418
tal number of persons vaccinated at ports of arrival because of compulsory-vaccination law	18,380
tal number of persons vaccinated at ports of departure or en route because of compulsory-vaccination law	19,962
tal number of persons vaccinated	38,342
umber of persons held in quarantine at the detention stations to complete the period of incubation of yellow fever and plague	3,274
umber of persons held in quarantine to complete period of incubation of smallpox	507
umber of persons held in quarantine on account of impetigo contagiosa	16
tal number of persons held on board vessels to complete period of incubation of yellow fever and plague	1,195
otal number of passengers landed from foreign ports:	
Cabin	17,289
Steerage	30,563
Total	47,852
otal number of passengers embarked for foreign ports:	
Cabin	15,546
Steerage	18,014
Total	33,560
pparent increase for the year from foreign ports:	
Cabin	1,743
Steerage	12,549
Total	14,292
otal number of persons arriving from coast towns on small launches and sailing craft	19,403
otal number of persons leaving for coast towns on small launches and sailing craft	14,782
pparent increase for the year from coast towns	4,621
umber of immigrants recommended for rejection	189
umber of certificates issued to outgoing passengers	764
umber of persons refused certificates because of trachoma	79
umber of bills of health issued	48
umber of bills of health viséed	344
otal number of circulars relative to malarial fever distributed	26,260
otal number of persons landed	67,255
otal number of persons embarked	48,342
otal apparent increase for the year	18,913

BOCAS DEL TORO.

Number of vessels inspected and passed	465
Number of persons vaccinated	34
Number of crew inspected	9,183
Number of passengers inspected	4,861
Number of persons held to complete period of incubation of yellow fever	287
Number of vessels sailing during the year	461
Number of vessels entering during the year	467

Personnel report (average number of employees per month for the year).

Office of chief sanitary officer	38	Tabernilla Dispensary	6
Property division, sanitary department	13	Corozal Dispensary	3
Quarantine service	31	Cristobal Dispensary	7
Health office:		San Pablo Dispensary	4
Panama	101	Gatun Dispensary	14
Colon-Cristobal	181	Pedro Miguel Dispensary	4
Office of director of hospitals	15	Ancon Dispensary	3
Ancon Hospital	455	La Boca Dispensary	6
Colon Hospital	246	Porto Bello Dispensary	3
Bas Obispo Dispensary [a]	11	Santo Tomas Hospital	8
Culebra Dispensary	17	Taboga Sanitarium	27
Empire Dispensary	12	Palo Seco Leper Asylum	6
Gorgona Dispensary	13	Zone sanitation	1,059
Miraflores Dispensary	14		
Paraiso Dispensary	11	Total	2,318
Las Cascadas Dispensary	10		

[a] Hospitals were operated at present dispensary and sick camp stations during the months of July and August.

APPENDIX M.

REPORT OF EDWARD J. WILLIAMS, DISBURSING OFFICER, ISTHMIAN CANAL COMMISSION.

EMPIRE, CANAL ZONE, *August 14, 1908.*

SIR: I have the honor to submit the following annual report for the fiscal year 1908:

On July 1, 1907, the work assigned to this office consisted of time inspection, timekeeping, and pay-roll preparation, vouchers, issuance of commissary and hotel coupon books, payment of all money on the Isthmus, and other work incidental to a disbursing office. By executive order of August 15, 1907, the duties connected with the time inspection were turned over to the examiner of accounts, and the property records and general books, showing the classification of expenditures and the keeping of statistics in regard thereto, were added to the duties of this office. This portion of the work was found to be considerably behind, but has, in the meantime, been brought as near current as such work can be. There has been decided improvement made in the returns from other departments, which, combined with the fact that the work was current in this office, has enabled reports to be made to the commission each month at a much earlier date than heretofore.

At the beginning of the past fiscal year employees from the United States, for convenience classed as "gold" employees, were paid monthly, while the laborers, classed as "silver" employees, were paid semimonthly. Since the beginning of October all employees of the commission have been paid once each month, and the change, it is believed, has been a decided benefit to all concerned.

On account of the former commission having required the disbursing office to check the time rolls against the time books, it was necessary, in order that this might be done prior to payment, to have the time books in periods of seven and eight days sent to this office for the preparation of a time roll and comparison to insure correctness. By placing the responsibility for this matter of preparation of rolls and checking of original time books against them with the division offices, it became practicable to prepare a time book such as has been in use since December 1, 1907, which permits each office in the field to use such number of time books each month as best promotes efficiency and the work in their individual case, the book being so arranged that no more than one book per month would be required for odd or even days, if so desired.

The issuance of hotel and commissary books has been safeguarded in different ways, as experience has shown to be practicable, until it is believed that the issuance is properly protected while at the same

time the furnishing of books to individuals has been placed on a businesslike basis and works out for the good of all concerned.

Pay roll and voucher forms have been changed during the year to meet conditions and to conform to the requirements of the new check system put in use by the Treasury Department, and everything is moving nicely in this portion of the work.

In order to expedite the handling of property returns and checking with the records of the division of material and supplies, it has been decided to transfer a small force from this office to that of the division of material and supplies at Cristobal, which will result in cutting out a duplication of work formerly necessary under the old system and will materially expedite the furnishing of reports required in that division of the work.

The present organization of the office divides the work into three principal divisions, viz: Voucher, pay, and accounts, all reporting to the disbursing officer, through the assistant disbursing officer, who is in direct charge of the detail work of the office and responsible therefor.

In this connection it might be interesting to consider some details of the work of the various divisions during the past year.

Our system of numbering pay rolls provides for each roll to bear the same basic number each month, and by prefixing the number of the month a glance at the roll will at once show the division of work to which referred and the month it covers. In this manner the outside offices can, with the least trouble, refer this office at any time to a particular item on any roll concerning which they may desire information.

In round numbers, the gold rolls for the fiscal year 1908 amounted to $8,874,000, and the silver rolls to $18,396,000 silver, or a gold equivalent of $9,188,000, making a total gold equivalent of $18,062,000. The items on the gold roll covered 70,486 payments and on the silver rolls 414,318 payments, making the average payment on the gold roll $125.80 and on the silver rolls $44.40 silver for the laborers, or an equivalent of $22.20 gold. This latter amount does not, however, in reality show the amount which each silver man will earn in a month, because of the fact that for about one-third of the time these men were paid twice a month. On this basis, they would show average earnings of a little less than $30 gold equivalent each per month.

It might be interesting to note that all Panamanian silver must be counted and rolled into convenient packages for payment and is packed into bags containing $1,000 silver, weighing 55½ pounds each. From this it will be noted that to pay the entire amount of the silver rolls for the past fiscal year would require 497.97 tons (of 2,000 pounds) of silver money, or a little more than 41 tons per month.

The deductions made on the pay rolls for the past fiscal year, covering hotel books, board, commissary coupon books, transportation, medical services, breakage, equipment, bond premiums, and miscellaneous total on the gold rolls amounted to $1,511,714.44 and on the silver rolls $1,523,660.34, making a grand total of $3,035,374.78.

An inspection of the unpaid salaries and wages accounts shows that from the inception of the work to date, on June 30, 1908, there was an unpaid balance due to employees of the commission of $190,636.84.

During the month of June, however, while there were unpaid i... for that month amounting to $59,170.61, there was paid durin... month on prior balances the sum of $57,354.59, showing that... present percentage remaining unpaid out of the total rolls ... month is quite small.

The payments of all amounts due from the commission are m... either at the main office at Empire, the branch offices at Ancon ... Cristobal, or from the pay car, which is run on the 12th, 13th, ... 14th of each month.

It will be recalled that under the old bankers' agreement the c... mission secured its money from four banking houses in Pana... such silver as was needed being delivered to the disbursing of... in exchange for his check on the subtreasury at New York, at ... rate of 2 pesos for each dollar of check, this being in accordance ... the parity of two for one, and the money for payment of gold rol... exchange for check on the subtreasury at New York dollar for d... and the additional payment in cash of three-fourths of 1 per c... for each dollar furnished by the bankers. This would have requi... an expenditure during the past year of, in round numbers, $66,... to cover the gold pay rolls alone, which amounted to $8,874,... The only expense the commission has been to in this regard was ... bringing down, during the year, of a total of $1,100,000 gold coin ... an expense of $4,125, which was paid to the Panama Railroad ... transportation charges thereon, thus showing a saving in this ... item of $62,430.

Each year the good results shown to the commission from my s... cessful efforts to prevent a renewal of this agreement are becom... more apparent. This condition of affairs has been made possi... by ability to use the postal receipts, amounting to in the neighborh... of $4,000,000 during the past year, principally from the sale of mon... orders, and to give in exchange therefor checks on the subtreasu... for all remittances required to be made to the Postmaster-General ... the United States for money-order purposes, and from the fact th... payments were made in gold coin, which, on account of its weig... could not profitably be mailed out of the country, and could n... under the laws of Panama, be exported by its merchants without ... payment of an export tax. When payments were made in paper... could at once be sent out by registered mail, and became in effect ... same as exchange on the United States, thus depleting our supply ... money each month and requiring additional shipments.

In addition to the saving made to the commission, the Pana... Railroad was paid in cash during the closing months of the fiscal ye... $457,685.34, thus enabling it to meet its pay rolls without importati... of coin.

In addition to having cared for the needs of the past fiscal year, ... is not believed that it will be necessary to make any additional ship- ments of gold for several months.

The records of the receiving teller show that during the past yea... there have passed through his hands a total of $4,287,402.25, of whi... however, $3,865,950.37 were for the Canal Zone government, all ... receipts, either for the commission or for the Canal Zone, being han- dled by one man.

During the fiscal year 308,742 commissary books, of a value of $1,591,385, and 51,198 hotel books, of a value of $744,958.80, were issued to employees, making a total issue of 359,940 books valued at $2,336,343.80, thus making a monthly issue of 29,995 commissary and hotel books combined. There are at present on hand 253,866 commissary books and 671,418 hotel books, valued at $1,304,727.50 and $976,967.40, respectively, making a total value of stock on hand of $2,281,694.90.

The stock clerk also handles the issue of postage stamps and postal cards for the Canal Zone, which amounted in full to $78,977.29 during the past fiscal year.

The records of the office show a total of 11,022 contract laborers received up to and including June 30, 1908, from whose pay deductions are made on account of transportation. Of this number 4,420 had on that date completed payment, and the remainder owed a balance amounting to $31,728.61, collections amounting to $252,429.89 net having been made during the past year.

The pay rolls of the department during the fiscal year amounted to $200,009.44, or an average per month of $16,647.45, and the total amount disbursed was $23,659,384.40 for the Isthmian Canal Commission, and also a further sum of $3,180,476.66 for the Canal Zone government. Tabulated statement showing more in detail the foregoing figures and also giving statistics as to expenditures of the various departments and the commission appropriations are appended hereto.

Respectfully,

EDWARD J. WILLIAMS,
Disbursing Officer.

Lieut. Col. GEO. W. GOETHALS, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.

APPENDIX 1.—*Collections made on pay rolls of the Isthmian Canal Commission during the fiscal year 1908.*

SILVER ROLLS.

Period.	Panama R. R. Com. coupon books.	Isthmian Canal Commission board.	Transportation.	Hotel books.	Lost metal checks.	Breakage.	Equipment.	Lost tools.	Medical service.	Lost property.	Bond premiums.	Miscellaneous bills.	Total.
1907.													
July 1-15	$30,728.26	$39,169.68	$17,301.90	$360.00	$187.67	$25.87	$14.40	$8.65	$4.00				$87,800.43
July 16-31	36,110.00	42,948.70	17,088.22	300.00	215.00	88.90	1.20	35.61	22.00	$37.80	$10.00		96,857.43
August 1-15	36,642.60	39,473.10	18,999.73	420.00	247.00	70.70	7.00	34.12	2.00				95,896.25
August 16-31	36,993.97	44,784.20	18,941.00	630.00	243.00	29.80	114.80	97.94	4.00			$10.00	101,848.71
September 1-15	38,919.68	39,776.18	19,115.80	630.00	165.00	101.54	2.40	9.64		5.80			98,726.04
September 16-30	42,851.16	44,752.33	19,343.79	750.00	241.00	150.43	109.10	67.44	8.00				108,273.25
October 1-31	104,896.91	91,644.71	42,227.38	1,249.20	473.00	160.10	32.26	19.52	8.00				240,711.08
November 1-30	122,566.41	89,370.00	57,088.27	828.00	435.00	195.64	51.60	30.36	20.00	12.90	10.00		270,608.18
December 1-31	127,085.60	91,633.90	49,261.97	879.60	452.00	252.59		22.00	24.00	5.80			269,617.66
1908.													
January 1-31	116,647.37	90,762.02	49,518.88	789.60	574.00	288.52	40.20	13.82	48.40		200.00		258,882.81
February 1-29	125,759.36	91,428.64	49,142.47	927.60	541.00	190.45	99.80	48.52	12.00				268,149.84
March 1-31	128,626.53	90,500.31	39,380.60	789.60	556.00	253.56	76.00	66.13	49.40			8.80	260,306.93
April 1-30	138,931.29	86,416.66	40,795.96	690.00	532.00	457.87	49.80	15.00	2.00	37.92		2.00	267,930.52
May 1-31	144,256.52	85,646.06	30,067.13	780.60	568.00	278.12	71.50	79.92	24.00	19.43		5.40	261,796.68
June 1-30	134,360.76	195,574.44	27,814.32	889.20	581.50		352.30		10.00	221.42		110.92	359,914.86
Total	1,365,376.42	1,163,880.93	496,087.44	10,913.40	6,011.17	2,544.09	1,022.36	548.87	237.80	341.07	220.00	137.12	3,047,320.67

GOLD ROLLS.

1907.													
July 1-31	$47,561.20	$3.40	$25.50	$51,590.81	$1.00	$1.20	$12.64	$0.50	$46.00		$105.00	$74.00	$99,421.25
August 1-31	52,566.79		8.00	52,865.28			7.35		72.00	$26.65	75.00	86.90	105,707.97
September 1-30	48,873.10		12.00	47,351.35	1.50		11.20	.78	115.00	14.14	85.00	140.20	96,604.27
October 1-31	64,700.83		38.00	57,203.46			16.15	.43	124.00		50.00	376.35	122,509.22
November 1-30	70,546.79		8.00	60,100.80	18.00		5.31	12.21	158.00	24.80	75.00	554.90	131,503.81
December 1-31	75,833.43		8.00	53,758.09	29.00		6.90	8.31	160.00	1.50		469.13	130,274.36
1908.													
January 1-31	78,123.50		124.00	56,455.67	29.00		9.10		132.00	9.78	1,190.00	472.03	136,545.08
February 1-29	79,332.50	35.20	35.00	53,690.92	29.00		24.50		185.00		35.00	407.05	133,774.17
March 1-31	79,265.25	30.00	14.80	53,811.52	36.50	6.40	11.95	2.14	101.50	1.25	85.00	513.91	133,880.22
April 1-30	81,203.33	30.00	24.00	54,996.69	33.00		28.60	.45	148.86	2.62	25.00	557.76	137,050.31
May 1-31	84,476.40	30.00	1.00	54,227.56	25.50	2.90	40.07	5.27	141.00	1.63	50.00	1,297.18	140,298.51
June 1-30	85,232.93	13.80	20.00	56,280.94	45.00		14.16	16.67	176.00	11.96	90.00	2,243.81	144,145.27
Total	847.716.05	142.40	318.30	652,333.09	247.50	10.50	187.93	46.76	1,559.36	94.33	1,865.00	7,193.22	1,511,714.44
Gold equivalent silver rolls	682,688.21	581,940.47	248,043.72	5,456.70	3,005.58	1,272.05	511.18	274.44	118.90	170.54	110.00	68.56	1,523,660.34
Total collections	1,530,404.26	582,082.87	248,362.02	657,789.79	3,253.08	1,282.55	699.11	321.20	1,678.26	264.87	1,975.00	7,261.78	3,035,374.78

Appendix 2.—*Pay rolls for the fiscal year 1908.*

SILVER ROLLS.

Period.	Total of rolls.	Amount unpaid on rolls at close of period.	Net amount paid during period.	[illegible]
1907.				
July 1-15	$703,076.82	$35,244.60	$667,832.22	[illegible]
July 16-30	800,339.39	38,488.85	761,850.54	[illegible]
August 1-15	738,426.87	36,272.31	702,154.56	[illegible]
August 16-30	825,943.55	30,275.05	795,668.50	[illegible]
September 1-15	710,481.75	34,047.74	676,434.01	[illegible]
September 16-30	772,559.89	22,337.90	750,221.99	[illegible]
October 1-31	1,593,260.63	22,915.85	1,570,344.78	[illegible]
November 1-30	1,509,825.64	28,770.41	1,481,055.23	[illegible]
December 1-31	1,475,859.10	34,472.96	1,441,386.14	[illegible]
1908.				
January 1-31	1,569,559.06	37,778.79	1,531,780.27	[illegible]
February 1-28	1,513,055.66	38,463.48	1,474,592.18	[illegible]
March 1-31	1,554,830.60	35,242.55	1,519,588.05	[illegible]
April 1-30	1,509,561.61	39,714.11	1,469,847.50	[illegible]
May 1-31	1,520,501.88	40,315.94	1,480,185.94	
June 1-30	1,598,756.40	49,032.97	1,549,723.43	
Total	18,396,038.85	....	17,872,665.34	[illegible]

Average payment of $43.14 per item, Panama silver.

GOLD ROLLS.

1907.				
July 1-31	$702,267.69	$42,257.41	$660,010.28	[illegible]
August 1-31	731,035.27	33,308.74	697,726.53	[illegible]
September 1-30	689,784.29	42,540.67	647,243.62	[illegible]
October 1-31	779,934.83	25,883.88	754,050.95	[illegible]
November 1-30	762,090.61	31,986.23	730,104.38	[illegible]
December 1-30	744,422.92	38,079.12	706,343.80	[illegible]
1908.				
January 1-31	753,234.39	33,343.97	719,890.42	[illegible]
February 1-28	732,152.57	40,786.16	691,366.41	[illegible]
March 1-31	751,749.41	41,408.05	710,341.36	[illegible]
April 1-30	738,296.40	40,089.65	698,206.75	
May 1-31	733,993.12	39,541.26	694,451.86	[illegible]
June 1-30	754,679.94	45,709.59	708,970.35	[illegible]
Total	8,873,641.44	....	8,418,706.71	[illegible]

Average payment of $119.43 per item, United States currency.

Appendix 3.—*Amounts handled by the receiving teller for twelve months ending J[illegible] 1908.*

	Cash.	Checks.	Cash for hunting licenses.	Total.
1907.				
July	$330,446.06	$4,729.85	$115.00	[illegible]
August	304,786.62	4,766.45	190.00	[illegible]
September	305,962.30	35,258.51	135.00	[illegible]
October	334,454.76	9,846.90	100.00	[illegible]
November	362,057.26	10,639.20	95.00	[illegible]
December	352,278.30	1,443.56	125.00	[illegible]
1908.				
January	403,662.29	1,366.43	160.00	[illegible]
February	386,139.79	1,153.52	80.00	[illegible]
March	368,155.44	1,609.41	60.00	[illegible]
April	368,399.15	2,303.01	30.00	[illegible]
May	346,824.64	1,100.15	15.00	[illegible]
June	346,438.34	2,015.31	460.00	[illegible]
Total	4,209,604.95	76,232.30	1,565.00	[illegible]

APPENDIX 4.—*Coupon books issued from disbursing officer's stock during fiscal year 1907–8.*

Month.	Commissary books.				Hotel books.	
	$2.50	$5	$10	$15	$4.80	$15
1907.						
July	5,405	9,500	....	1,071	....	3,655
August	9,930	12,159	....	1,165	620	4,921
September	9,148	11,190	....	1,681	....	3,597
October	14,649	10,343	....	1,837	290	3,800
November	9,235	19,360	....	2,206	260	4,675
December	6,050	16,285	....	1,760	210	4,101
1908.						
January	6,651	17,505	....	3,240	110	4,488
February	6,565	17,307	....	2,480	100	4,208
March	5,865	16,965	....	2,150	76	3,595
April	7,550	18,880	4,111	2,209	120	4,275
May	6,745	15,380	6,865	....	110	3,427
June	5,185	14,665	5,450	....	360	4,200
Total	92,978	179,539	16,426	19,799	2,256	48,942

Commissary books issued during fiscal year	308,742
Hotel books issued during fiscal year	51,198
Total	359,940

Average monthly issue.

	First six months.	Last six months.	Fiscal year.
Commissary books	23,829	27,628	25,729
Hotel books	4,355	4,178	4,266
Total coupon books	28,184	31,806	29,995

Value of commissary books issued during fiscal year	$1,591,385.00
Value of hotel books issued during fiscal year	744,958.80
Total	2,336,343.80
Stock of commissary books on hand June 30, 1908	253,866
Stock of hotel books on hand June 30, 1908	67,418
Total	321,284
Value of stock of commissary books on hand June 30, 1908	1,304,727.50
Value of stock of hotel books on hand June 30, 1908	976,967.40
Total	2,281,694.90

APPENDIX 5.—*Disbursing office pay rolls for fiscal year 1908.*

	Gold.	Silver.	Total gold equivalent.
1907.			
July	$15,218.65	$1,529.83	$15,983.57
August	16,593.66	1,645.11	17,416.21
September	14,789.09	1,697.11	15,637.65
October	16,077.00	1,702.22	16,928.11
November	16,526.40	1,625.00	17,338.90
December	17,714.91	1,610.67	18,520.24
1908.			
January	17,243.41	1,624.66	18,055.74
February	15,603.26	1,435.34	16,320.93
March	15,560.47	1,370.39	16,245.67
April	15,815.36	1,413.33	16,522.02
May	14,561.67	1,558.33	15,340.84
June	14,905.90	1,587.33	15,699.57
Total	190,609.78	18,799.32	200,009.44

APPENDIX 6.—*Statement of receipts, disbursements, and balances available to J[illegible] 1908.*

RECEIPTS.

Appropriations by Congress (Exhibit A)			$141[illegible]
Collections account sale of government property, etc. (Exhibit B)			3[illegible]
Balance due individuals and companies, account collections from employees			[illegible]
Total receipts			144[illegible]

DISBURSEMENTS.

Classified expenditures (Exhibit C)			76[illegible]
Department of civil administration		$2,146,996.77	
Department of sanitation		6,925,910.77	
Department of construction and engineering		35,874,846.14	
Canal construction	$30,104,095.27		
Municipal improvements on zone	3,533,618.70		
Municipal improvements in Panama and Colon	2,237,132.17		
Cost of plant		31,099,300.04	
Rights of way and franchises			49[illegible]
Rights acquired from Republic of Panama		10,000,000.00	
Rights acquired from New Panama Canal Company		39,168,651.28	
Payment to New Panama Canal Company	40,000,000.00		
Less value of French material sold or used in construction	831,348.72		
Panama Railroad Company stock purchased			[illegible]
Loans to Panama Railroad Company for reequipment and redemption of bonds			4[illegible]
Paid into United States Treasury for sale of government property, etc			3[illegible]
Services rendered and material sold to individuals and companies			2[illegible]
Unclassified expenditures			4[illegible]
Material and supplies on hand		3,916,075.22	
Payments to Panama Railroad Company		19[illegible]43.30	
Other unclassified items		25,329.42	
Advances to laborers for their transportation			[illegible]
Total			13[illegible]
Less amounts included above, but unpaid on June 30, 1908			1[illegible]
Salaries and wages unpaid on pay rolls, prior to June 1, 1908		190,636.84	
Pay rolls for the month of June, 1908		1,487,780.88	
Net disbursements			137[illegible]
Balances available June 30, 1908			7[illegible]
Congressional appropriations (Exhibit D)		7,214,470.03	
Collections account sales of government property, etc		3,870.78	
Collections from employees account, individuals and companies		3,828.35	
Total			144[illegible]

NOTE:—By an act of May 27, 1908, additional appropriations were made to continue the constr[illegible] the Isthmian Canal during the fiscal year 1909, available for expenditures July 1, 1908, as follows.

Expenses in the United States	$17[illegible]
Construction and engineering	23,4[illegible]
Civil administration	2[illegible]
Sanitation and hospitals	1,5[illegible]
Reequipment of Panama Railroad	1,[illegible]
Relocation of Panama Railroad	1,0[illegible]
Purchase of two ships	1,[illegible]
Total	29,17[illegible]

EDWARD J. WILLIAMS,
Disbursing O[illegible]

EMPIRE, CANAL ZONE, *August 14, 1908.*

EXHIBIT A, APPENDIX 6.—*Statement of appropriations by Congress.*

Purchase of canal rights, June 28, 1902		$40,000,000.00
Purchase of canal zone rights, April 28, 1904		10,000,000.00
Construction of canal, June 28, 1902		10,000,000.00
Construction of canal, December 21, 1905		11,000,000.00
Construction of canal, February 27, 1906		5,990,786.00
Construction of canal	$5,340,786.00	
Reequipment of Panama Railroad	650,000.00	
Construction of canal, June 30, 1906		25,456,415.08
Expenses in the United States	368,242.69	
Construction, engineering, and administration	21,018,537.24	
Civil administration	968,200.00	
Sanitation and hospitals	2,101,435.15	
Reequipment of Panama Railroad	1,000,000.00	
Construction of canal, March 4, 1907		27,161,367.50
Expenses in United States	253,000.00	
Construction, engineering, and administration	20,366,000.00	
Civil administration	825,000.00	
Sanitation and hospitals	2,034,000.00	
Reequipment of Panama Railroad	1,385,000.00	
Purchase of Panama Railroad bonds	2,298,367.50	
Construction of canal, February 15, 1908		12,178,900.00
Expenses in United States	18,600.00	
Construction, engineering, and administration	11,990,400.00	
Sanitation and hospitals	169,900.00	
Total appropriations by Congress		141,787,468.58

EMPIRE, CANAL ZONE, *August 14, 1908.*

EXHIBIT B, APPENDIX 6.—*Detail of receipts for sale of property, services rendered, etc., which revert to the United States Treasury as miscellaneous receipts, to June 30, 1908.*

Sale of Isthmian Canal property		$936,165.43
Sale of property	$852,977.38	
Sale of French material and equipment	81,632.62	
Sale of water	255.43	
Sale of shares of Panama Railroad stock	1,300.00	
Rental of Isthmian Canal property		471,015.19
Rent of lands and buildings	42,677.24	
Rent of equipment	311,047.33	
Panama waterworks and sewers rentals	71,971.75	
Colon waterworks and sewers rentals	31,573.00	
Rentals, miscellaneous	13,745.87	
Work done by Isthmian Canal Commission		208,716.34
Labor furnished, Panama Railroad Co	180,336.97	
Other labor furnished	28,379.37	
Miscellaneous		1,104,261.09
Hotel coupon books	52,508.97	
Hotels and boarding camps	737,747.76	
Hospital messes	46,879.48	
Laundry receipts	7,382.01	
Receipts from pay patients	79,901.04	
Quarantine subsistence	24,900.53	
Receipts from corrals	8,628.56	
Telegraph and telephone service	3,547.35	
Miscellaneous	93,629.41	
Interest on loans to Panama Railroad Co	49,135.98	
Subsidies and dividends		419,945.00
Annual subsidy from Panama Railroad Co	75,000.00	
Dividends on Panama Railroad stock	344,945.00	
Total		3,140,103.05

EMPIRE, CANAL ZONE, *August 14, 1908.*

EXHIBIT C, APPENDIX 6.—*Classified statement of expenditures to June 30, 19[illegible]*

Department of civil administration:	
Administration	[illegible]
Judiciary	[illegible]
Revenues and posts	[illegible]
Education	[illegible]
Police and prisons	[illegible]
Fire and military protection	[illegible]
Maintenance and operation waterworks and sewers, Panama and Colon	[illegible]
Repairs and maintenance of pavements, Panama and Colon	[illegible]
Miscellaneous zone public works	[illegible]
Total, department of civil administration	[illegible]
Department of sanitation:	
Hospitals and asylums	[illegible]
Sanitation	[illegible]
Total, department of sanitation	[illegible]
Department of construction and engineering, construction of canal:	
Dry excavation	24,[illegible]
Dredging excavation	[illegible]
Gatun dam	[illegible]
Gatun locks	[illegible]
La Boca dam	[illegible]
La Boca locks	[illegible]
Pedro Miguel dam	[illegible]
Pedro Miguel locks	[illegible]
Miraflores dam and spillway	[illegible]
Miraflores locks	[illegible]
Total, canal construction	30,124,[illegible]
Municipal improvements:	
Panama waterworks and sewers	[illegible]
Colon waterworks and sewers	[illegible]
Paving Panama	[illegible]
Paving Colon	[illegible]
Zone waterworks and sewers	[illegible]
Zone roadways	1,174,[illegible]
Total, municipal improvements	[illegible]
Plant:	
Panama Railroad second main track	1,017,[illegible]
Relocation Panama Railroad	[illegible]
Rolling stock	[illegible]
Excavating machinery	[illegible]
Floating equipment	[illegible]
Shop and other machinery and tools	[illegible]
Rails, fastenings, and ties	[illegible]
Construction electric light plants	173,[illegible]
New buildings—	
Construction and engineering	[illegible]
Civil administration	[illegible]
Sanitation	[illegible]
Docks and wharves	[illegible]
Lands purchased	[illegible]
Corral equipment	[illegible]
Total, plant	31,099,[illegible]
Grand total	76,047,062.[illegible]

1908.

	aterial nd ex- enses, al Zone.	Pay of sanitary officers and employees on Isthmus.	Sanitary pay rolls on Isthmus.	Material and expenses on Isthmus, sanitary department.	Redemption of Panama R. R. bonds.	Canal connecting Atlantic and Pacific oceans.
Balances July 1						
United Sta	,008.27	$80,000.00	....	$238,478.34	....	$812.82
E. J. Willis	,319.82	57,054.07	$59,850.19	53,728.88	....	946,189.96
J. G. Jester	,298.46	....	....	16,143.54	....	106,173.09
Le Roy Pa	....	....	....	....	....	9,671.06
W. J. Karn	....	....	....	....	....	2,093.39
Appropriat	,000.00	766,000.00	468,000.00	800,000.00	$2,298,367.50	....
Appropriat	....	....	169,900.00	....	....	....
Direct settl	....	....	....	....	....	1,606.15
Collections repo						
By E. J. W	275.63	23,624.74	13,170.48	41,887.35	....	2,655.69
By J. G. Je	....	....	....	68.73	....	3,949.47
Repayments de						
By E. J. W						74.83
By M. C. G	....	....	....	5.95	....	....
By Ham. F	....	....	....	....	150.00	....
Transfer of	....	....	....	....	....	....
Settlements wi July 1, 19	....	....	....	....	....	1,508,813.97
Total...	,902.18	926,678.81	710,920.67	1,150,312.79	2,298,517.50	2,582,040.43
By E. J. Willia	,763.18	760,067.90	484,156.84	349,493.05	....	723,348.92
By J. G. Jester	,182.02	....	17.30	190,332.95	....	31,004.44
By Le Roy Par	....	....	....	....	....	9,462.32
By W. J. Karn	....	....	....	....	....	12,093.39
By Ham. Fish	....	....	....	....	2,148,367.50	....
Direct settleme	,993.40	120.00	....	31,222.19	....	22,999.72
Transfer of app	,649.21	6,971.62	34,934.76	130,225.10	....	....
Settlement with July 1, 1907..	,686.42	....	2,499.70	39,669.95	....	41,088.78
Total....	,274.23	767,159.52	521,608.60	740,943.24	2,148,367.50	839,997.57
BAL						
In U. S. Treasu	,365.66	78,908.38	124,033.24	347,037.00	150,150.00	85,494.08
With disbursin						
E. J. Willia	,832.27	80,610.91	64,795.83	41,123.18	....	225,496.73
J. G. Jester	,430.02	....	483.00	21,209.37	....	1,425,843.31
Le Roy Par	....	....	....	....	....	208.74
W. J. Karn	....	....	....	....	....	5,000.00
Total ava	,627.95	159,519.29	189,312.07	409,369.55	150,150.00	1,742,042.86

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EDWARD J. WILLIAMS, *Disbursing Officer.*

	1908.	Prior to July 1, 1907, taken up in 1908.	Total, 1908.	Prior to July 1, 1907.	Total to date.
Department of civil administration:					
Administration	$59,616.50	$2.44	$59,618.94	$249,106.78	$308,725.72
Judiciary	67,506.86	1,695.17	69,202.03	129,857.85	199,059.88
Revenues and posts	142,085.82	3,885.17	145,970.99	368,126.67	514,097.66
Education	616.72	48,498.37	47,881.65	50,170.57	2,288.92
Police and prisons	252,478.11	8,854.63	261,332.74	505,031.83	766,364.57
Fire and military protection	104,012.61	2,904.45	106,917.06	99,190.32	206,107.38
Maintenance and operation waterworks and sewers, Panama and Colon	66,401.75	2,117.19	68,518.94	67,657.30	136,176.24
Repairs and maintenance pavements, Panama and Colon	7,699.30	....	7,699.30	....	7,699.30
Miscellaneous zone public works	4,192.48	14,903.79	10,711.31	17,188.41	6,477.10
Total	704,610.15	48,948.11	660,667.04	1,486,329.73	2,146,996.77
Department of sanitation:					
Hospitals and asylums	1,221,689.47	46,855.15	1,268,544.62	2,286,446.43	3,554,991.05
Quarantine	47,661.40	2,673.57	50,334.97		
Sanitation, Panama and Colon	224,998.73	8,590.31	233,589.04	2,244,367.30	3,370,919.72
Zone sanitation	815,862.41	26,766.00	842,628.41		
Total	2,310,212.01	84,885.03	2,395,097.04	4,530,813.73	6,925,910.77
Department of construction and engineering:					
Dry excavation	12,805,224.68	577,718.96	13,382,943.64	11,283,490.20	24,666,433.84
Dredging excavation	1,263,887.96	2,290.44	1,266,178.40	817,922.35	2,084,100.75
Gatun dam	828,294.46	6,520.17	834,814.63	170,688.66	1,005,503.29
Gatun locks	802,136.13	14,638.24	816,774.37	324,655.92	1,141,430.29
La Boca dams	217,152.27	10,175.12	206,977.15	127,307.75	334,284.90
La Boca locks	201,087.59	86.83	201,174.42	63,116.89	264,291.31
Pedro Miguel dam	5,655.32	123.97	5,779.29	1,415.35	7,194.64
Pedro Miguel locks	105,519.07	2,179.96	107,699.03	39,489.56	147,188.59
Miraflores dam and spillway	40,690.91	....	40,690.91	....	40,690.91
Miraflores locks	411,012.07	1,964.68	412,976.75	....	412,976.75
Total	16,680,660.46	595,348.13	17,276,008.59	12,828,086.68	30,104,095.27
Municipal improvements:					
Panama waterworks and sewers	26,833.22	59,654.51	86,487.73	767,361.50	853,849.23
Colon waterworks and sewers	51,113.74	13,917.09	65,030.83	536,013.08	601,043.91
Zone waterworks and sewers	818,519.04	58,828.43	877,347.47	1,481,492.97	2,358,840.44
Paving Panama	43,544.82	15,995.99	59,540.81	429,466.96	489,007.77
Paving Colon	92,987.41	85,738.70	178,726.11	114,505.15	293,231.26
Zone roadways	461,958.18	21,527.74	483,485.92	691,292.34	1,174,778.26
Total	1,494,956.41	255,662.46	1,750,618.87	4,020,132.00	5,770,750.87

APPENDIX 7.—*Statement of consolidated expenditures for fiscal year ending June 30, 1908, and to June 30, 1908*—Continued.

	1908.	Prior to July 1, 1907, taken up in 1908.	Total, 1908.	Prior to July 1, 1907.	Total to date.
Plant account:					
Panama R. R. second main track	$118,670 12	$470,623 00	$589,294 08	$428,039 30	$1,017,333 38
Relocation of Panama R. R.	1,436,254 1[illegible]	45,[illegible] 31	1,481,[illegible] 48	104,04[illegible] 82	1,586,013 30
Rolling stock	1,807,843 45	152,994 76	1,960,838 21	5,014,028 26	6,974,866 47
Excavating machinery	1,140,218 40	75,302 81	1,215,521 40	1,780,068 20	2,995,590 [illegible]
Floating equipment	2,798,016 80	12,858 00	2,811,274 80	1,664,783 40	4,476,058 20
Shop and other machinery and tools	647,330 14	27,000 93	674,331 07	783,213 08	1,457,544 15
Rails and fastenings	648,110 73	22,888 18	671,098 91	1,890,200 00	3,030,663 05
Ties	430,007 73	41,370 43	469,374 16		
Construction of electric-light plants	90,827 32	565 98	91,433 30	82,006 37	173,439 67
New buildings—					
Department of construction and engineering	2,340,135 00	180,331 33	2,490,467 32	7,101,868 04	9,588,330 36
Department of civil administration	40,010 81		40,010 81		40,010 81
Department of sanitation	80,731 08		80,731 08		80,731 08
Docks and wharves	90,511 01	4,014.97	94,017 34	417,333 34	509,180 08
Lands purchased	333 73		333 73	50,088 03	50,411 30
Corral equipment	5,101 90		5,101 90		5,101 90
Total	11,084,213 16	1,006,308 41	12,090,521 60	18,909,767 48	31,000,[illegible] 08
Total expenditures	32,874,034 18	1,898,298 92	34,772,013 10	41,274,140 00	76,047,000 79

EDWARD J. WILLIAMS, *Disbursing Officer.*

EMPIRE, CANAL ZONE, *August 5, 1908.*

APPENDIX 8.—*Statement of classified expenditures, fiscal year ended June 30, 1908.*

	Salaries.	Material.	Incidentals.	Collections.	Total.
Department of civil administration:					
Administration	$41,684.68	$258.91	$2,305.34		$43,736.11
Judiciary	47,867.62	3,586.01	1,603.06	$5.00	53,051.69
Revenues and posts	133,198.12	6,226.62	29,585.09	68,529.88	100,479.95
Education		424.91	20.92		445.83
Police and prisons	183,158.33	10,221.48	10,998.23	4,508.89	199,869.65
Fire protection	51,009.82	32,424.83	2,123.60	157.04	85,461.21
Military protection	1,658.93	49.07			1,708.00
Maintenance and operation of waterworks and sewers:					
Panama	15,657.87	4,190.25	656.96	186.09	20,318.99
Colon	24,898.46	7,718.80	1,368.12	79.75	33,905.63
Repairs and maintenance of pavements:					
Panama	1,378.30	351.75	26.00		1,756.05
Colon	2,194.97	990.13	175.44		3,360.54
Miscellaneous, zone public works	2,647.60	10.09	394.79	7.00	3,045.48
Construction of buildings		43,365.42			43,365.42
Repairs of buildings		5,909.17			5,909.17
Total	505,414.70	115,214.62	49,858.15	73,473.15	597,014.32
Department of sanitation—administration	80,377.59	9,335.39	6,607.13	12.18	96,307.93
Hospitals and asylums	585,021.81	389,855.03	69,574.63	92,266.74	952,184.73
Quarantine	29,031.60	15,031.57	3,856.62	13,912.55	34,006.24
Sanitation, Panama and Colon	98,636.05	20,268.20	68,376.58	2,569.67	184,711.16
Zone sanitation	476,890.47	86,241.15	53,160.10	693.30	615,598.42
Construction of sanitary buildings		75,492.89			75,492.89
Repairs to sanitary buildings		17,176.70			17,176.70
Total	1,269,957.52	613,400.93	201,575.06	109,454.44	1,975,478.07
Department of construction and engineering—canal construction:					
Administration	166,176.17	9,248.20	5,838.35	133.60	181,129.12
Dry excavation	7,121,551.50	2,969,679.92	443,612.59	10,518.50	10,524,325.51
Dredging excavation	701,268.19	331,867.68	11,219.28	7,956.91	1,036,398.24
Gatun dam and spillway	461,931.08	180,407.36	32,909.80		675,248.24
Gatun locks	486,126.79	152,954.67	10,765.40	.95	649,845.91
La Boca dam and spillway	115,113.66	64,913.96	3,697.74		183,725.36
La Boca locks	116,507.03	43,578.50	7,371.12	175.40	167,281.25
Pedro Miguel dam	3,654.25	852.69	.01		4,506.95
Pedro Miguel locks	33,711.87	17,845.46	41,185.97		92,743.30
Miraflores dam and spillway	17,406.47	7,440.98	9,591.48		34,438.93
Miraflores locks	249,416.01	59,620.77	19,159.67		328,196.45
Total—canal construction	9,472,863.02	3,828,410.19	585,351.41	18,785.36	13,867,839.26

APPENDIX 8.—*Statement of classified expenditures, fiscal year ended June 30, 1908*—Continued.

	Salaries.	Material.	Incidentals.	Collections.	Total.
Department of construction and engineering—division of municipal engineering:					
Superintendence and other expenses	$44,639.20	$1,311.07	$8,310.04	$19.84	$54,240.47
Waterworks and sewers:					
Panama	14,340.44	6,047.60	515.51	195.18	20,708.51
Colon	24,742.44	15,280.90	2,444.83	602.61	41,865.56
Zone waterworks and sewers	360,135.85	274,799.66	24,982.79	812.94	659,105.36
Paving:					
Panama	20,719.17	8,566.55	1,219.43	1.50	30,503.65
Colon	27,652.46	37,742.41	15,862.86	.60	81,257.13
Zone roadways	175,753.28	132,343.22	54,917.55	....	363,014.05
Miscellaneous	503.96	96.79	9.61	....	610.36
Total—division of municipal engineering	668,486.80	476,188.29	108,262.62	1,632.62	1,251,305.09
Department of construction and engineering—division of building and construction:					
Superintendence and other expenses	111,234.86	2,532.99	88,985.22	208.23	202,549.84
Construction of buildings	1,198,931.21	914,706.43	26,972.43	6,267.19	2,134,342.88
Repairs of buildings	494,524.68	256,300.14	4,265.42	5,205.02	749,885.22
Total—division of building and construction	1,804,690.75	1,173,539.56	120,223.07	11,675.44	3,086,777.94
Total—department of construction and engineering	11,946,040.57	5,488,138.04	813,837.10	32,093.42	18,215,922.29
Department of labor quarters and subsistence:					
Administration	126,359.58	16,594.97	6,670.09	122.65	149,501.99
Recruiting	27,727.28	1,335.19	177,018.81	180.70	205,901.98
Quarters	346,557.11	286,759.18	101,160.49	4,821.81	729,654.97
Operation of gardens and truck farms	2,039.25	123.44	216.50	894.85	1,237.96
Hotels, messes and kitchens	318,215.81	1,534,393.45	19,451.68	1,600,048.75	283,108.88
Total	820,899.03	1,838,959.35	305,614.21	1,605,707.26	1,319,705.33
Plant account:					
Rolling stock	202,259.59	1,502,980.75	65,261.24	181.00	1,770,270.58
Excavating machinery	142,658.80	945,277.39	7,428.08	4.61	1,095,300.26
Floating equipment	315,036.01	2,333,480.24	54,140.33	....	2,702,008.58
Shop and other machinery and tools	109,088.67	424,044.70	18,801.76	....	613,135.22
Rails and fastenings	582.19	629,110.38	....	1,481.66	628,240.91
Ties	....	408,727.29	....	11,005.88	397,721.41
Lands purchased	333.73	....	....	....	333.73
Docks and wharves	752.40	87,022.87	7,504.88	266.46	95,074.70
Construction of electric-light plants	20,457.70	56,515.77	2,204.14	18.91	[illegible]
Corral equipment	....	4,668.00	246.00	70.00	4,[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Miscellaneous:					
General expenses, Isthmian Canal Commission	133,953.31	30,440.07	67,209.36	780.05	230,822.69
Disbursing officers	224,391.54	22,241.20	7,319.16	4,562.67	249,389.23
Examiners of accounts	96,163.93	2,755.14	1,814.14	....	100,733.21
Transportation on Isthmus	137,470.96	43,192.80	145,437.17	6,230.68	319,870.32
Panama R. R., second main track	305.34	49,287.04	68,659.28	....	118,252.26
Relocation of Panama R. R	211,111.22	520,379.71	670,760.34	3,342.87	1,398,908.40
Telegraph and telephones	836.21	5,404.55	92,289.20	401.65	98,128.31
Moving and care of French machinery and equipment	14,171.73	3,389.01	32.77	....	17,593.51
Construction and furnishing Santa Tomas Hospital	45.72	217.36	....	....	263.08
Operations and repairs of electric-light plants	13,787.24	15,463.03	4,588.27	72.75	24,589.25
Salaries and expenses:					
On Isthmus	374,742.35	1,688.19	220,429.33	2,647.68	590,840.86
In United States	56,620.47	80.08	38,685.47	31.33	95,417.35
Freight, advertising and miscellaneous items	383.33	....	125,270.02	210.08	125,863.43
Total	1,263,983.37	691,167.40	1,433,317.97	17,796.84	3,370,671.90
RECAPITULATION.					
Department of civil administration	505,414.70	115,214.62	49,858.15	78,478.15	597,014.32
Department of sanitation	1,269,957.52	613,400.93	201,575.06	109,455.44	1,975,478.07
Department of construction and engineering	11,946,040.57	5,488,138.04	813,837.10	82,098.42	18,215,922.29
Department of labor, quarters and subsistence	820,899.03	1,838,959.35	265,614.21	1,605,707.26	1,319,765.33
Plant account	860,769.27	6,392,289.54	155,742.01	12,998.55	7,395,802.27
Miscellaneous	1,263,983.37	691,167.40	1,433,317.97	17,796.84	3,370,671.90
Total expenditures	16,667,064.46	15,139,169.88	2,[illegible],344.50	1,851,524.66	32,874,654.18

EDWARD J. WILLIAMS, *Disbursing Officer.*

EMPIRE, CANAL ZONE, *August 8, 1908.*

APPENDIX 9.—*Statement of classified expenditures for period prior to July 1, 1907, and taken into account during fiscal year ending June 30, 1908.*

	Salaries.	Material.	Incidentals.	Collections.	Total.
Department of civil administration:					
Administration	$3,412.52	$336.43	$1,464.84		$4,540.98
Judiciary	679.17	572.81	121.29		227.65
Revenue and posts	1,065.00	5,547.70	5,569.94		1,042.76
Education		495.46	49,356.65	$8.80	49,848.81
Police and prisons		1,016.65	779.98		1,796.63
Fire protection		1,144.92	107.28	157.04	1,409.24
Military protection		179.35			179.35
Maintenance and operation waterworks and sewers—					
Panama		9.10	36.68		45.78
Colon		526.14			526.14
Miscellaneous zone public works	171.67		16,880.58	557.65	16,101.26
Total	4,985.02	2,257.76	61,279.48	723.49	67,798.77
Department of sanitation:					
Administration		424.29	88.25		462.54
Hospitals and asylums	619.20	22,763.28	1,197.08	214.58	22,399.98
Quarantine		369.12	88.68	1,050.20	1,385.04
Sanitation	189.95	899.19	602.52	411.29	75.88
Zone sanitation		5,682.58	848.67	141.28	5,475.19
Total	429.25	27,491.50	1,015.16	1,817.35	28,722.94
Department of construction and engineering—canal construction:					
Administration		4,315.84	460.25		4,770.09
Dry excavation	28,596.46	367,685.34	14,790.06	9,526.82	368,406.36
Dredging excavation	2.50	18,896.52	852.95	3,563.13	15,188.84
Gatun dam and spillway	1,875.00	845.57	329.09		3,049.66
Gatun locks	1,875.00	4,175.45	280.40	3.06	5,823.71
La Boca dam and spillway		18,874.96	28.60		18,898.56
La Boca locks	489.92	537.95	11.20		80.83
Pedro Miguel dam			.56		.56
Pedro Miguel locks	1,875.00		90.08		1,965.08
Miraflores dam and spillway					
Miraflores locks	1,875.00		80.08		1,955.08
Total—canal construction	16,588.88	345,288.67	15,142.77	13,003.01	356,001.17
Department of construction and engineering—division of municipal engineering:					
Superintendence and other expenses		1,640.63	51.99		1,692.62
Waterworks and sewers—					
Panama		57,004.55	188.42	70.40	50,017.50
Colon	27.28	7,[illegible]	[illegible]	[illegible]	[illegible]
Zone waterworks and sewers	880.00	[illegible]	[illegible]	[illegible]	[illegible]

Paving—					
Panama		10,242.96	1,246.56	9.96	11,499.48
Colon		39,589.13	40,950.07	1,030.20	81,569.40
Zone roadways		7,213.64	5,302.34		12,515.98
Total—division of municipal engineering	808.82	163,278.08	47,380.27	1,543.04	211,398.07
Department of construction and engineering—division of building and construction:					
Superintendence and other expenses	100.00	2,917.37	232.58	10.85	3,060.80
Construction of buildings	24,326.05	109,001.07	511.41	7,635.99	140,451.70
Repairs of buildings	979.25	15,487.08	806.16	4,702.93	20,363.10
Total—division of building and construction	25,205.30	127,405.52	1,084.99	12,349.77	163,875.60
Total—department of construction and engineering	7,868.10	635,972.27	61,438.05	26,986.42	732,264.84
Department of labor, quarters and subsistence:					
Administration	25.01	2,160.67	923.30	1,504.85	4,613.83
Recruiting		199.66	35,797.58		35,997.24
Quarters	50.00	35,010.50	179.61	318.36	35,558.47
Hotels, messes, and kitchens	206.40	238,373.23	6,428.42	26,777.99	218,230.06
Total	281.41	275,744.06	43,328.91	24,954.78	294,399.60
Plant account:					
Rolling stock		164,070.52	149.61	73.85	163,994.76
Excavating machinery		73,651.64	44.00	1,895.17	75,502.81
Floating equipment		12,652.44	205.56		12,858.00
Shop and other machinery and tools		14,078.56	12,922.37		27,000.93
Rails and fastenings		9,800.51	80.00	13,127.67	22,898.18
Ties		22,428.45	77.68	19,025.65	41,376.42
Docks and wharves			4,675.18	60.86	4,614.27
Construction of electric-light plants		595.98			595.98
Total		297,278.10	8.151.51	34,183.20	339,612.81
Miscellaneous:					
General expenses, Isthmian Canal Commission	1,977.51	6,146.03	14,283.48		22,407.02
Disbursing officers	9.71	1,578.71	200.72	.01	1,789.13
Examiners of accounts		274.12	1,170.11		895.99
Transportation on Isthmus		25,503.32	7,238.27	2,644.81	20,909.86
Panama R. R., second main track	62,452.76	215,981.93	191,940.03	249.24	470,623.96
Relocation of Panama R. R		45,409.06		329.25	45,738.31
Telegraph and telephones		11,610.35	2,228.91		9,381.44
Moving and care of French machinery and equipment			5.00		5.00
Constructing and furnishing Santo Tomas Hospital		671.92	180.00		491.92
Operation and repairs of electric-light plants		768.20		76.94	845.14
Salaries and expenses—					
On Isthmus		478.77			478.77
In United States	19.76	174.67	85.46		240.37
Freight, advertising, and miscellaneous items			.11		.11
Total	64,420.22	307,039.54	195,697.51	3,300.23	571,057.50

APPENDIX 9.—*Statement of classified expenditures for period prior to July 1, 1907, and taken into account during fiscal year ending June 30, 1908*—Continued.

	Salaries.	Material.	Incidentals.	Collections.	Total.
RECAPITULATION.					
Department of civil administration	$4,985.02	$2,257.76	$61,279.48	$723.49	$67,798.77
Department of sanitation	429.25	27,491.50	1,015.16	1,817.35	28,722.94
Department of construction and engineering	7,868.10	635,972.27	61,438.05	26,986.42	732,204.84
Department of labor quarters and subsistence	281.41	275,744.06	43,328.91	$4,954.78	294,309.60
Plant account		297,278.10	8,151.51	34,183.20	339,012.81
Miscellaneous	64,420.22	307,630.54	195,097.51	3,300.23	571,057.80
Total expenditures	68,013.96	1,541,807.71	240,321.34	42,055.91	1,898,258.92

EMPIRE, CANAL ZONE, *August 7, 1908.*

EDWARD J. WILLIAMS, *Disbursing Officer.*

APPENDIX N.

REPORT OF W. W. WARWICK, EXAMINER OF ACCOUNTS.

EMPIRE, CANAL ZONE, *August 7, 1908.*

SIR: I have the honor to submit the following report of the business of the department of examination of accounts of the Isthmian Canal Commission, including also work done as auditor of the Canal Zone government for the fiscal year ended June 30, 1908. This department was created by executive order of August 15, 1907, when the positions of general auditor and local auditor were abolished. As I arrived on the Isthmus June 5, 1908, to take charge of the work of the department, this report covers but a few weeks of the time I have been in charge and is in substance a report of the work done under my predecessor, Mr. H. L. Stuntz.

This office has given the administrative examination to the accounts of the disbursing officer before their transmission to the Auditor for the War Department. During the year 13 accounts have been received, involving about 6,500 vouchers, including the pay rolls. These rolls were supported by about 400,000 pay certificates. No substantial differences were found as a result of this administrative examination made of the disbursing officer's accounts after the vouchers were made up and paid by him. The examiner was required by the executive order to check the pay rolls of employees engaged upon a monthly or yearly basis from the appointment records. This has been done by a check from the personnel records kept in the disbursing office. The appointment records are kept at Culebra, and it was impracticable to make the check from such original records. A better plan than that now in use will be devised as it is evident that a check of the disbursing officer's pay rolls from the records kept by him is not the best that can be had.

Inspections of the accounts of all officials of the commission on the Isthmus charged with the care of funds or property of the commission have been carried on so far as the force of the office would permit. There are 122 offices to be inspected, and the total number of inspections was 208. The offices included those in the revenue service, divisions of schools and police, clerks of courts, hospitals, dispensaries, hotels, clubhouses, post-offices, and timekeepers in various departments. In addition to the inspection, this office has witnessed and certified to the transfer of various offices from one person to another. It has also witnessed and verified the destruction of coupon books when for any reason the books of this class were to be destroyed.

The force has been engaged for many days during the year in taking inventories of property in various branches of the service. It has not been practicable, however, to take a complete inventory of all

property on the Isthmus. The examiner has, however, been re- sented when inventories were taken by officers charged with custody of property.

The cash in the hands of all officers intrusted with public mone the Isthmus has been counted and the balances verified at inspection. The cash in the hands of the disbursing officer has counted and found correct with the exception of minor discrepan

A large part of the force connected with this office has been enga outside of the office in the work of time inspection. About inspectors have been employed in checking the time books in hands of timekeepers and foremen engaged upon the work in departments, as well as the force employed by the Panama Rail Company. These inspectors examine time books in the hands of timekeepers or foremen and see that the men credited with are present or accounted for. These inspections are made at irreg times and an effort is made to correct errors and to prevent crediting of more time to employees than they have worked, whe such time is given through error or intentionally. The force inspectors is always busy because of the fact that there are 1,500 gangs to be inspected, and they are scattered all over Isthmus. It is believed that this work of inspection has resu in the correction of many errors and the prevention of mistakes intentional overcrediting of time. The time inspectors have been engaged for short periods in the work of taking inventories property.

The duty assigned to the examiner of checking collections made the disbursing officer from the record of claims payable to the co mission has been performed so far as practicable under the outlined when the duty was assigned to him. At the suggestion the examiner, all claims due the commission from its employees w deducted from June salaries, and hereafter there will be no accum tion of claims by the commission against its own employees.

One of the duties assigned to the office is to report to the chairm any irregularities in the accounts or books of any officer or employ of the commission. There have been many irregularities reporte but they were not important and none but such as could be correct by suitable instructions. They related more to the unintention violation of rules prescribed by the chairman than to any actu wrongdoing.

ACCOUNTS OF THE CANAL ZONE GOVERNMENT.

Since the organization of the government of the Canal Zone i 1904, the accounting officers of the Isthmian Canal Commission hav been assigned the duty of auditing the accounts of the Canal Zo government, and the same duty was assigned to the examiner accounts when his department was created. During the year accounts were received from tax collectors, district judges, circu court clerks, the collector and deputy collectors of revenues, and th treasurer of the Canal Zone. These accounts have been audite The cash in the hands of the treasurer of the Canal Zone was count in January, 1908.

By the act of March 4, 1907, section 2, Congress appropriated th revenues of the Canal Zone until and including June 30, 1908, an

required that the revenues of the postal service should be used for the maintenance of that service and that the remaining revenues, after setting aside a miscellaneous and contingent fund of $10,000, should be applied to the maintenance of the public-school system in the Zone and to public improvements within the Zone. By section 3 of the act of May 27, 1908, Congress made provision for the appropriation of funds of the Zone thereafter collected. This required a change from the plan of expenditures provided for in the act of March 4, 1907, so that the requirements of the 1907 act as to the disposition of revenues to and including June 30, 1908, was superseded, and the act of May 27, 1908, governs the disposition of funds collected on and after the date of that act. It is substantially the same disposition of the revenues as was ordered in the 1907 law.

I inclose statements showing the revenues collected from March 4, 1907, to June 30, 1907, by districts; the revenues collected between July 1, 1907, and June 30, 1908, by districts; the total receipts and disbursements of revenues, as well as the disposition of trust funds.

I inclose also a statement showing the postal business by post-offices and other figures relating to the postal business of the Canal Zone for the fiscal year ended June 30, 1908. This statement shows that the money orders issued during the year were of the value of $4,686,684.98 and that the money-order fees amounted to $19,309.14.

The work assigned to the department of examination of accounts may, in general terms, be said to be that of inspection of the books, records, and accounts of all officers and employees charged with the receipt, custody, and payment of money, and the receipt, custody, issue, and use of property. The expenditures for canal construction exceed $30,000,000 per annum, and from the records of this office and my personal observation during the short time I have been on the Isthmus, it is evident that the work is being done with almost, if not quite, the minimum amount of loss by irregularities or dishonesty. The organization of the large force engaged on the Isthmus is such as to secure accurate work. The character of men employed is such that it would be difficult to find anywhere as large a force without finding a larger number of incompetent men and those of a lower standard of honesty.

The work of those employed in this department has been well performed. Considering the number employed, the amount of work has been large, and it has been service of a high standard.

Respectfully,

W. W. Warwick,
Examiner of Accounts.

Lieut. Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.

APPENDIX 1.—*Revenues collected between March 4, 1907, and June 30, 1907, by ad[illegible]istrative districts in the Canal Zone.*

On account of—	Administrative districts.				Total.
	Ancon.	Empire.	Gorgona.	Cristobal.	
Animal licenses	$3.00			$0.25	[illegible]
Burial permits	45.75	$45.75	$45.75	45.75	[illegible]
Carts and coaches		5.00	7.00	112.75	[illegible]
Court collections:					
Circuit	187.81	187.82	187.81	187.82	[illegible]
District	1,259.60	3,011.30	1,330.55	1,275.95	[illegible]
Feeding prisoner	84.90			65.00	[illegible]
Hunting permits	86.25	86.25	86.25	86.25	[illegible]
Internal revenues	379.08	379.07	379.06	379.07	[illegible]
Land and building rental	4.25	300.00	327.80	52.00	[illegible]
Market space		291.00	359.40	423.73	[illegible]
Merchandise tax	544.80	1,935.22	1,212.35	964.34	[illegible]
Miscellaneous	62.64	95.10	25.00	342.61	[illegible]
Pipe-line license	375.00	375.00	375.00	375.00	[illegible]
Police fines	36.66	36.67	36.67	36.67	[illegible]
Poll tax	24.00	350.00		400.00	[illegible]
Professional licenses	2.50	7.50	8.50	2.50	[illegible]
Public entertainments	8.00	106.02	68.00	41.50	[illegible]
Real estate:					
1907	1,361.99	520.41	1,034.85	975.43	[illegible]
1908	37.50	2.00			[illegible]
Restaurants and hotels	79.30	38.00	84.20	56.30	[illegible]
Slaughter of animals	21.00	3,110.00	1,417.75	148.80	[illegible]
Water and sewer rental	327.35	68.90	74.90		[illegible]
Total	4,931.18	10,822.91	7,060.76	6,029.72	[illegible]

APPENDIX 2.—*Revenues collected between July 1, 1907, and June 30, 1908, by administrative districts of the Canal Zone.*

On account of—	Administrative districts.				Total.
	Ancon.	Empire.	Gorgona.	Cristobal.	
Animal licenses	$21.00	$180.00	$166.00	$35.50	[illegible]
Burial permits	265.75	265.75	265.75	265.75	[illegible]
Carts and coaches		126.45	21.20	713.55	[illegible]
Court collections:					
Circuit	1,698.36	1,698.37	1,698.38	1,698.42	[illegible]
District	5,553.85	11,705.30	6,443.87	6,714.75	[illegible]
Insurance deposits	32.25	32.25	32.26	32.26	[illegible]
Internal revenue	6,053.74	6,053.74	6,053.73	6,053.73	[illegible]
Hospital revenues	15.00	15.00	15.00	15.00	[illegible]
Land and building rentals	3,964.26	5,577.11	8,539.03	4,723.99	[illegible]
Market space	96.00	2,035.64	1,566.00	2,036.60	[illegible]
Merchandise tax	4,192.65	15,279.23	10,717.72	4,723.98	[illegible]
Miscellaneous	7,532.75	7,589.12	7,529.95	7,555.30	[illegible]
Poll tax	1,310.00	652.40	408.00	799.60	[illegible]
Professional license		2.20	3.00		[illegible]
Public entertainments	20.00	723.50	370.00	112.00	[illegible]
Real estate:					
1907	1,554.53	555.00	913.70	559.83	[illegible]
1908	3,019.35	4,096.00		1,292.75	[illegible]
Restaurants and hotels	195.00	634.80	291.90	274.00	[illegible]
Slaughter of animals	119.50	7,954.00	3,826.00	1,549.50	[illegible]
Water and sewer rental	605.30	1,069.80	879.97	439.30	[illegible]
Refundment				2.74	2.74
Total	36,249.29	66,245.66	49,741.46	39,598.55	191,834.[illegible]

APPENDIX 3.—*Revenue account, March 4, 1907, to June 30, 1908.*

Collected prior to March 4, 1907		$134,781.10	
Collections, March 4, 1907, to June 30, 1907		28,844.57	
Balance turned over by municipalities		1,176.70	
Refundment		59.23	
Collected and disbursed by municipalities, March 4 to April 14, 1907		12,313.32	
Collections, July 1, 1907, to May 26, 1908		170,892.23	
Collections, May 27, 1908, to June 30, 1908		20,942.73	
			$369,009.88
Postal revenue account, March 4, 1907, to June 30, 1908:			
Sale of stamps to June 30, 1907	$21,634.46		
Money-order fees to June 30, 1907	4,537.12		
		26,171.58	
Sale of stamps, year ended June 30, 1908	72,709.54		
Money-order fees, year ended June 30, 1908	19,309.14		
		92,018.68	
			118,190.26
Total Canal Zone revenues			487,200.14

APPENDIX 4.—*Disbursement of Canal Zone revenues, March 4, 1907, to June 30, 1908.*

	Public improvements.	Schools.		
From March 4 to June 30, 1907:				
From revenues collected prior to March 4, 1907			$17,504.40	
Collected and disbursed by municipalities, March 4 to April 14, 1907			12,313.32	
Miscellaneous and contingent expenses			20.00	
Public improvements and schools			18,098.16	
Ancon district	$1,901.75	$3,532.16		
Empire district	5,149.82	1,319.32		
Gorgona district	1,876.25	1,204.79		
Cristobal district	1,856.24	1,257.83		
	10,784.06	7,314.10		
From July 1, 1907, to June 30, 1908:				
From revenues collected prior to March 4, 1907			8,673.41	
Miscellaneous and contingent expenses			[illegible]	
Public improvements and schools			77,281.00	
				$131,794.02
Ancon district	$8,010.07	$7,733.18		
Empire district	29,430.09	7,395.09		
Gorgona district	4,435.06	7,372.94		
Cristobal district	6,923.25	7,979.64		
	46,800.27	30,480.89		
Postal service:				
Paid for stamps			[illegible]	
Paid Isthmian Canal Commission			[illegible]	
				[illegible]
Total disbursements				[illegible]

APPENDIX 5.—*Statement of exchange of postal money orders between the Canal Z[illegible] Isthmus of Panama, and the United States of America, for the fiscal year ended J[illegible] 1908.*

	July, 1907.	Aug., 1907.	Sept., 1907.	Oct., 1907.	Nov., 1907.	Dec. [illegible]
Total orders issued	$347,869.84	$311,906.35	$332,307.95	$351,937.63	$381,561.20	$4[illegible]
Drawn on United States	281,131.16	241,006.40	254,035.31	276,303.88	287,235.96	3[illegible]
United States orders paid	3,399.56	2,209.55	1,417.30	1,835.50	1,899.88	[illegible]
Drawn on United States and repaid in Canal Zone	4,403.94	2,975.12	3,173.42	4,163.92	3,899.92	5,1[illegible]
Orders paid by United States Post-Office Department	260,201.48	234,609.81	198,593.34	225,093.54	351,244.81	2[illegible]
Remittances to United States Post-Office Department	205,000.00	215,000.00	260,000.00	230,000.00	230,000.00	3[illegible]
Canal Zone orders drawn on Canal Zone	66,738.68	70,901.95	78,272.64	75,633.75	94,325.24	9[illegible]
Canal Zone orders paid in Canal Zone	62,239.74	52,905.35	53,668.67	63,289.94	59,697.84	5[illegible]
Money-order fees	1,444.64	1,256.02	1,377.79	1,442.32	1,579.04	1,[illegible]

	Jan., 1908.	Feb., 1908.	Mar., 1908.	Apr., 1908.	May, 1908.	June, 1[illegible]
Total orders issued	$427,899.25	$418,739.57	$430,437.16	$445,979.48	$403,108.14	$4[illegible]
Drawn on United States	301,491.34	289,947.77	306,666.63	320,405.58	285,645.07	3[illegible]
United States orders paid	2,819.89	4,000.62	4,029.37	2,982.28	3,118.05	3,[illegible]
Drawn on United States and repaid in Canal Zone	2,594.81	4,512.58	4,827.76	7,126.77	5,766.57	6,[illegible]
Orders paid by United States Post-Office Department	256,311.11	263,938.40	275,952.46	324,926.38	284,165.31	....
Remittances to United States Post-Office Department	245,000.00	290,000.00	260,000.00	245,000.00	290,000.00	265,[illegible]
Canal Zone orders drawn on Canal Zone	126,407.91	128,791.80	123,770.53	125,573.90	117,463.07	118,[illegible]
Canal Zone orders paid in Canal Zone	70,381.79	73,231.59	98,502.54	114,228.51	114,450.09	116,[illegible]
Money-order fees	1,736.19	1,710.85	1,782.15	1,846.05	1,668.30	1,[illegible]

Orders payable in United States	$3,460,7[illegible]
Orders payable in Canal Zone	1,225,[illegible]
Total	4,686,[illegible]
Orders drawn on United States and paid in United States (105,193)	2,875,[illegible]
Orders drawn on United States and repaid in Canal Zone	54,7[illegible]
Orders drawn on Canal Zone and paid in Canal Zone	963,[illegible]
Orders outstanding and unpaid, July 1, 1907, to June 30, 1908	793,[illegible]
Total	4,686,684.[illegible]

APPENDIX 6.—*Statement showing the postal business of the Canal Zone, Isthmus of Panama, for the fiscal year ended June 30, 1908, by post-offices.*

MONEY ORDERS ISSUED.

Post-office.	Total issued.	Drawn on United States.	Drawn on Canal Zone.
Ancon	$329,373.46	$278,523.95	$50,849.51
Ancon, Station A [a]	67,510.53	60,868.15	6,642.38
Bas Obispo	127,622.82	83,689.06	43,933.76
Bohio	11,833.17	9,216.44	2,616.73
Corozal	58,651.39	42,293.08	16,358.31
Cristobal	715,794.66	641,471.54	74,323.12
Culebra	569,961.69	397,245.44	172,716.25
Empire	698,274.47	492,691.02	205,583.45
Gatun	212,871.87	169,821.06	43,050.81
Gorgona	589,929.97	416,452.60	173,477.37
La Boca	177,940.99	118,114.32	59,826.67
Las Cascadas	275,171.86	184,285.24	90,886.62
Matachin	43,239.01	37,025.55	6,213.46
Paraiso	277,799.90	187,288.65	90,511.25
Pedro Miguel	291,558.59	179,602.70	111,955.89
San Pablo [b]	69,342.06	40,420.46	28,921.60
Tabernilla	169,808.54	121,745.99	48,062.55
Total	4,686,684.98	3,460,755.25	1,225,929.73

Post-office.	Money orders.			Revenues.	
	Drawn on United States, repaid in Canal Zone.	Issued in United States, paid in Canal Zone.	Issued in Canal Zone, paid in Canal Zone.	Money-order fees.	Postage sales.
Ancon	$3,671.91	$5,671.42	$70,443.63	$1,476.52	$8,373.01
Ancon, Station A [a]	640.30	934.99	10,919.45	286.92	1,565.63
Bas Obispo	757.60	1,435.65	30,327.04	523.60	1,837.38
Bohio	221.00	124.03	1,699.10	62.55	341.68
Corozal	290.88	1,281.12	8,244.30	253.56	1,045.14
Cristobal	9,148.88	8,464.75	92,628.52	3,060.36	16,474.94
Culebra	8,735.35	3,130.16	149,830.61	2,310.72	7,728.58
Empire	4,520.36	3,326.45	161,501.30	2,800.22	8,753.91
Gatun	900.45	1,208.85	21,281.90	952.49	4,065.15
Gorgona	8,499.72	2,492.12	126,674.01	2,300.23	6,484.00
La Boca	1,278.86	772.06	39,762.35	727.41	2,667.28
Las Cascadas	4,797.91	305.10	62,952.86	1,087.71	3,247.00
Matachin	702.35	201.40	2,476.14	224.93	1,159.51
Paraiso	3,544.81	1,830.46	56,554.30	1,092.02	2,797.69
Pedro Miguel	4,546.84	1,619.15	85,525.83	1,182.89	2,730.00
San Pablo [b]	707.59	103.36	13,539.50	274.13	1,207.15
Tabernilla	1,758.97	477.38	28,666.35	692.88	2,231.49
Total	54,723.78	33,378.45	963,027.19	19,309.14	72,709.54

[a] Ancon, Station A, discontinued April 30, 1908. [b] San Pablo, established January 1, 1908.

APPENDIX 7.—*Receipts and disbursements, July 1, 1907, to June 30, 1908, by [illegible] headings of account.*

	Balances July 1, 1907.	Revenues.	Disbursements.	Balances.	In hands of collecting officers.	[illegible]
Miscellaneous and contingent:						
1907	$756.63			$756.63		[illegible]
1908	9,980.00		$904.24	9,075.76		[illegible]
1909		$10,000.00		10,000.00		[illegible]
Public improvements and schools:						
1907	104,206.75	52.53	5,673.41	98,585.87		[illegible]
1908	14,243.13	170,892.23	77,251.09	107,884.27		[illegible]
1909		10,942.73		10,942.73	$1,839.08	[illegible]
Postal receipts:						
1908	15,171.58	84,501.63	99,673.21			
1909		7,517.05		7,517.05	228.50	[illegible]
Total	144,358.09	283,906.17	183,501.95	244,702.31	2,067.58	242,[illegible]

APPENDIX 8.—*Money-order funds, July 1, 1907, to June 30, 1908.*

	Receipts.	Disbursements.	Balances.
Balance, July 1, 1907	$247,606.22		
Sales	4,686,684.98		
Disbursed by postmasters		$1,051,129.42	
Remitted to Postmaster-General of the United States		3,055,000.00	
Balance in hands of treasurer, June 30, 1908			$812,[illegible]
Balances in hands of postmasters, June 30, 1908			15,[illegible]
Total	4,934,291.20	4,106,129.42	828,[illegible]

APPENDIX 9.—*Trust funds, July 1, 1907, to June 30, 1908.*

Fund.	Receipts.	Disbursements.	Balances.	In hands of collectors.	In treasury.
Y. M. C. A. clubhouses	$56,570.66	$47,171.65	$9,399.01	$303.71	$9,0[illegible]
Circuit courts	22,896.12	14,303.12	8,593.00	8,593.00	
District judges	18,128.20	17,855.15	273.05	273.05	
Administrator of estates	6,347.67	5,028.69	1,318.98	1,318.98	
Total	103,942.65	84,358.61	19,584.04	10,488.74	9,0[illegible]

APPENDIX 10.—*Treasurer's balance, June 30, 1908.*

Revenues	$242,[illegible]
Money-order funds	812,[illegible]
Y. M. C. A. deposits	9,0[illegible]
Total	1,064,17[illegible]

APPENDIX O.

REPORT OF A. BRUCE MINEAR, GENERAL SECRETARY, YOUNG MEN'S CHRISTIAN ASSOCIATION OF THE CANAL ZONE.

CULEBRA, CANAL ZONE, *August 6, 1908.*

SIR: I have the honor to submit the following report of work conducted in the commission clubhouses, under the supervision of the Young Men's Christian Association, during the fiscal year ending June 30, 1908:

The beginning of the fiscal year was marked by the formal opening of the clubhouse at Cristobal. Similar equipments at Culebra, Empire, and Gorgona had been in operation a month. The secretaries in charge had been carefully selected from those of special training and successful experience. Closely associated with each secretary has been an executive council representing the varied interests of the membership. From the beginning these organizations have continued in healthy condition and have developed a spirit of association brotherhood by which members promote the welfare of one another, rather than by a spirit of selfish gain.

The associations are democratic, without forced congeniality, and each member recognizes that within the clubhouse he meets other officials and employees only as man to man. This has produced very noticeable results in eliminating caste distinction that had previously threatened the highest welfare of employees. The membership is thoroughly representative of all classes of white gold employees, and the skilled mechanics constitute about 59 per cent of the total.

The clubhouses were planned to accommodate a membership of 250 to 300 each, but the total number of members in the four associations has varied from 1,327 to 1,727. During the fiscal year more than 3,000 different employees have availed themselves of membership privileges and have contributed an average of $4,480.87 per month toward the operating expenses. The membership has constituted an average of 55 per cent of all white gold employees living in the four towns having clubhouses.

The balance of the gold population has given liberal patronage to public entertainments and "open-house" receptions. Visiting contractors and other guests have been appreciative of the courtesies extended them. Social clubs, women's clubs, and kindred organizations have been given the use of the entertainment halls for regular and special occasions. Altogether the clubhouses have served practically the entire white population of the respective towns.

A conservative estimate of the attendance, based on actual counts during periods of seven successive days, is placed at 1,208 p[illegible] average for the year. There have been 95 entertainmen[illegible] high-grade lyceum and vaudeville talent imported f[illegible]

for this purpose, and the attendance at these has aggregated ... Local talent has been used for 131 entertainments, with a total attendance of 23,550, exclusive of functions of social clubs. The recorded games in bowling have totaled 64,247 and in pool and billiards 1...

The association members have organized themselves into ... small clubs for special activities, such as chess, checker, glee, minstrel, camera, and orchestra clubs, and 498 men have thus associated themselves in congenial groups. Likewise those interested in Sunday meetings and concerts have held 116 gatherings, with an attendance of 7,996, and 129 men have engaged in weekly Bible discussions.

Educational classes have been conducted of evenings in Spanish, arithmetic, mechanical drawing, English grammar, shorthand, first aid, and wireless telegraphy. Three hundred and ninety-one different students have followed these courses.

The gymnasiums provided originally proved inadequate and physical work has been conducted in the entertainment halls. Seven hundred and fifty-five different men have engaged in systematic gymnasium work, and such games as basket, volley, and indoor baseball, and their total attendance has been 9,253. Three ... meets, exclusively association, have been held on holidays, and the associations cooperated in the field sports of additional holidays.

The soda fountains, together with ice cream and bottled ... drinks, have proven a great social attraction and have kept men from the saloons. The gross receipts from this service were $15,399.02.

Well-equipped barber shops have been added to the clubhouse equipment and first-class American barbers placed in charge.

The average number of men voluntarily serving on committees at any given time was 175. About 880 calls were made on members sick in hospitals. Facilities for letter writing were used to the extent of about 5,000 letters per month.

In November the commission installed a library of 500 volumes in each clubhouse, and to these the associations have added new books each month. All books of fiction, biography, and history are circulating. No charge is made for the use of books and deposits insure their return. During the eight months since the libraries were installed 736 members have withdrawn 9,039 books. These are also read largely by the families of members. In each clubhouse the association furnishes a reading room, with 100 current periodicals.

A boys' department has been organized in each association for the accommodation of boys over 10 years of age. Games and outings are conducted on certain days, under the strict supervision of secretaries.

In the last week of June a temporary work was established in Camp Hope and Camp Diablo, United States Marines, for the welfare of the 1,300 marines stationed on the Isthmus during the Panamanian election period.

In February the International Committee of Young Men's Christian Associations sent their associate general secretary, Mr. C. J. Hicks, of New York, to inspect the associations on the Canal Zone and the work was approved by him as heartily as it has been by the advisory committee, who have judged from the commission's point of view.

Considering the appreciation which employees have shown for the advantages offered through the club houses, together with their liberal use of same and the results obtained, it would seem proper to recommend that the work be extended to additional towns where there are sufficient numbers of employees to warrant.

All properties under the care of the associations have been regularly accounted for, whether furnished by the Commission or purchased from Young Men's Christian Association funds. All accounts of the associations have been regulated by the commission's examiner of accounts. The financial policy of the associations has been determined each month by the advisory committee appointed for that purpose by the commission. That committee is composed as follows: Col. W. C. Gorgas, chief sanitary officer; W. G. Tubby, chief division of material and supplies; H. L. Stuntz, local auditor Panama Railroad Company; Joseph Bucklin Bishop, secretary Canal Commission; A. Bruce Minear, general secretary Young Men's Christian Associations.

Respectfully submitted.

A. Bruce Minear,
General Secretary Young Men's Christian Associations of the Canal Zone.

Lieut. Col. George W. Goethals, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.

APPENDIX P.

REPORT OF LIEUT. COL. H. F. HODGES, CORPS OF ENGINEERS, U. S. ARMY, GENERAL PURCHASING OFFICER AND CHIEF OF THE WASHINGTON OFFICE.

WASHINGTON, D. C., *July 6, 1908.*

SIR: I have the honor to submit the following report upon the organization and work of this office during the fiscal year ended June 30, 1908:

On the 1st of July, 1907, under an executive order of the President, the purchase of materials and supplies was transferred to the supervision of the Chief of Engineers, United States Army, who was authorized to maintain a purchasing department in the office of the Isthmian Canal Commission in Washington; and on the 15th of August, 1907, this office was reorganized, under executive order of that date, since when it has comprised the following divisions, all under my immediate charge as general purchasing officer and chief of office of the Isthmian Canal Commission, namely: General office, general counsel, disbursing office, assistant examiner of accounts; appointment, correspondence, and record divisions, and purchasing department.

In addition, the designing and drafting force connected with the engineering department on the Isthmus, engaged in designing the movable dam and gates for the locks, has continued to occupy quarters in the Washington office. A part of the inspecting engineer's office was transferred from New York to Washington on March 9, 1908, and quarters also provided for them here.

On the 1st of September, last year, the three upper floors of the Mills Building Annex, until then wholly occupied by this commission, were given up and leased directly to the Navy Department, the remaining five floors and basement of this building being now the quarters of the commission in this city.

As heretofore, the general office has been charged with the preparation of all general correspondence, the immediate supervision of appointments, correspondence and records, and the care of the building, office fixtures, and supplies.

The general counsel continues in charge of all legal matters pertaining to the commission and the Panama Railroad Company, both in the United States and on the Isthmus of Panama.

The appointment division during the last twelve months tendered 2,160 persons within the United States employment on the Isthmus in grades above that of laborer; 1,947 accepted and were appointed,

covering 154 different positions; 5,397 persons, including new appointees, those returning from leave of absence, and members of their families, have been provided with transportation from the United States to the Isthmus during the fiscal year under review. In response to inquiries and applications for employment in this time 21,241 letters have been written, 3,178 telegrams sent, and 36,000 circulars mailed.

The work of the correspondence and record divisions has been continued as outlined in the last annual report.

The assistant examiner of accounts has continued the work of the office of the general auditor by bringing the work and records of that office up to June 30, 1907, and examining, so far as received, the accounts and vouchers prepared and paid since by the disbursing officer of the commission in the United States and the special disbursing officers in Europe and the West Indies, besides making an inspection of the office books and accounts of the disbursing officer in Washington up to and including June 30, 1908.

The disbursing division, charged with the safe receipt and disbursement of the funds of the commission in the United States upon proper vouchers, reports a volume of business for this fiscal year (1908) amounting to:

Claim statement, fiscal year 1908.

On hand July 1	$55	
Received July 1 to June 30	11,105	
		$11,160
Passed for settlement July 1 to June 30		10,956
On hand June 30		204

Financial statement.

Balance on hand, July 1, 1907		$212,215.18
Receipts from United States Treasury	$14,044,730.56	
Collections:		
Liquidated damages, account of delays in deliveries	74,038.05	
Cash discounts	5,918.62	
Miscellaneous	1,840,978.27	
		15,965,665.50
Disbursements, claims settled	13,728,288.51	
Deposited in United States Treasury:		
"Miscellaneous receipts"	315,953.78	
Repayment to appropriations	539,977.55	
		14,584,219.84
Balance on hand June 30, 1908		1,593,660.84

The purchasing department is charged with the purchase of all supplies, machinery, and necessary plant required for use on the Isthmus and elsewhere, and is under the direct supervision of the general purchasing officer, with headquarters in Washington, and with assistant purchasing and shipping agents located at New York, New Orleans, Tacoma, and San Francisco. All orders and contracts for the delivery of material and supplies are placed by this department.

Circular invitations for bids are prepared from the requisitions received from the Isthmus and distributed directly from the office of the general purchasing officer, assistant purchasing and shipping agents, and through commercial agencies in certain cities, and during